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JOURNAL OF THE
AERONAUTICAL SCIENCES

Volume 4 JULY, 1937 Number 9

Winds in the Upper Troposphere and the Lower Stratosphere Over the United States

LOYD A. STEVENS, *U. S. Weather Bureau, Washington, D. C.*

Presented at the Meteorology Session, Fifth Annual Meeting, I. Ae. S. January 28, 1937

DURING September, 1935 a committee was formed, under the supervision of the Bureau of Air Commerce, for the purpose of studying the problems of high-altitude flying. The United States Weather Bureau was, of course, represented on this committee and one of the meteorological questions asked of the Bureau, was "What kind of winds will be encountered at levels of 20,000 ft. and above?" To answer this question intelligently, it was necessary to summarize and analyze the upper air wind records for these high levels. These data were accordingly summarized for a total of 30 selected stations for the five levels of 6, 8, 10, 12, and 14 km., corresponding approximately to 20, 26, 33, 39, and 46 thousand ft., respectively, above sea level. The deciding factors in the selection of these stations were their geographical location and the number of observations reaching high levels. The data were treated by seasons—the months of December, January, and February being considered as winter; March, April, and May being considered as spring, etc. Average values were obtained for all seasons and levels having a total of 15 or more observations. The study consists of wind roses, resultant winds, average velocities, the frequency of high velocities, and extreme velocities. Each of these will be discussed below in the order named.

Wind Roses

The wind roses shown in the accompanying charts are of the usual type wherein the length of each line represents the percentage frequency of the wind from that particular direction and the numbers at the ends of the lines are average velocities in meters per second. The annual data for the 6 km. level are shown in Fig. 1. It will be noted that in general the prevailing directions are between WSW and NW at all stations. This is also true at 8 and 10 km. The average velocities are, as a rule, highest from the prevailing directions. At Groesbeck, Texas, for example, the average velocities for the prevailing directions (W and WNW) are 15 m.p.s. while the average for winds in the southeast quadrant, which are least frequent, are only 5 or 6 m.p.s. An increase in average velocities with latitude is also apparent; the average for the prevailing directions varying from 10 or 11 m.p.s. over the extreme southern part of the country to 15 or 16 m.p.s. over the northern part. At this level (6 km.), therefore, there would be a decided advantage in flying a northern route east-bound and a southern route west-bound. There is, in general, an increase in velocity from all directions with height, especially over the southern part of the country as may be seen by comparing the 6 and 12 km. annual charts (Figs. 1 and 2). For example, at Brownsville, Texas, the average velocity of the prevailing direction (W) at 6 km. is 11 m.p.s., while at 12 km. it is 17 m.p.s. At Ellendale, on the other hand, there is little change in the average velocity of the prevailing direction between 6 and 12 km., the average for WNW being 16 m.p.s. at 6 km. and 17 m.p.s. at 12 km. The apparent increase in frequency of N to NE winds over the southeastern part of the country at 12 and 14 km.

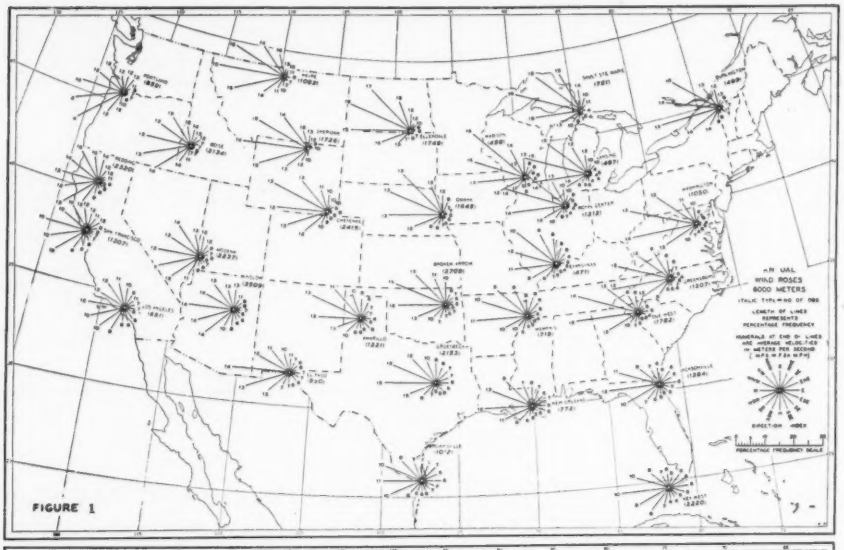
ANNUAL
WIND ROSES
8000 METERS
ITALIC TYPE = NO. OF OBS.
LENGTH OF LINES REPRESENTS PERCENTAGE FREQUENCY
NUMERALS AT END OF LINES ARE AVERAGE VELOCITIES IN METERS PER SECOND
DIRECTION INDEX
PERCENTAGE FREQUENCY SCALE

FIGURE 1

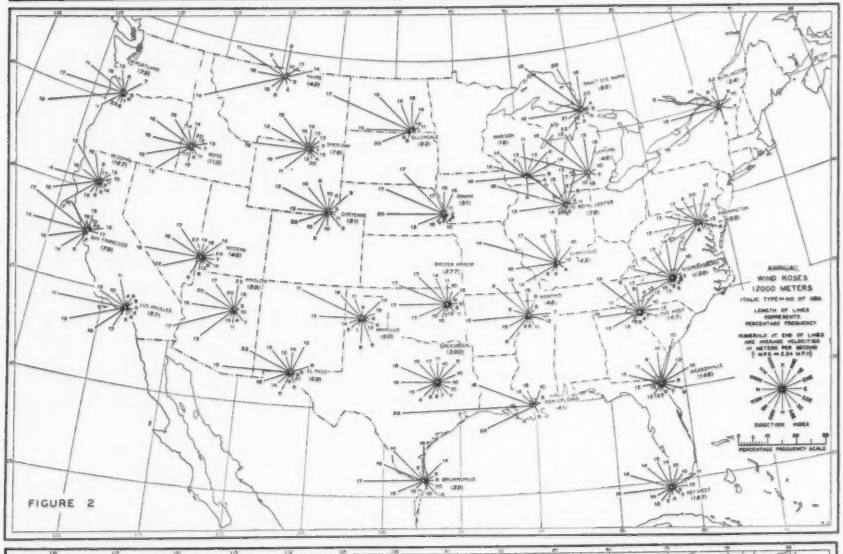
ANNUAL
WIND ROSES
12000 METERS
ITALIC TYPE = NO. OF OBS.
LENGTH OF LINES REPRESENTS PERCENTAGE FREQUENCY
NUMERALS AT END OF LINES ARE AVERAGE VELOCITIES IN METERS PER SECOND
DIRECTION INDEX
PERCENTAGE FREQUENCY SCALE

FIGURE 2

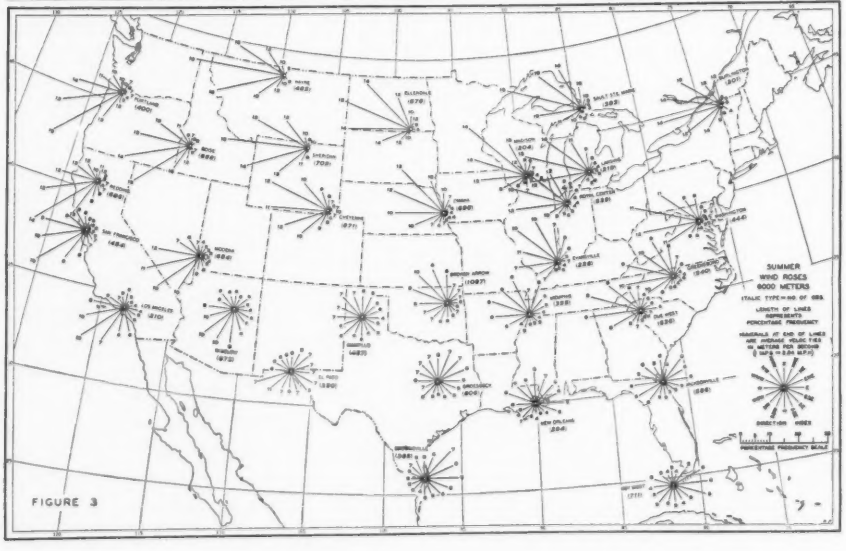
SUMMER
WIND ROSES
8000 METERS
ITALIC TYPE = NO. OF OBS.
LENGTH OF LINES REPRESENTS PERCENTAGE FREQUENCY
NUMERALS AT END OF LINES ARE AVERAGE VELOCITIES IN METERS PER SECOND
DIRECTION INDEX
PERCENTAGE FREQUENCY SCALE

FIGURE 3

is probably due to the fact that most of the observations reaching these levels, at stations located in this area, were made during the summer and autumn months when winds from the northeast quadrant are most frequently observed.

In Fig. 3 are shown the wind roses for 6 km. during the summer season. It will be seen that the northward movement of the belt of northeast trade winds during this season, causes a decided increase in the frequency of easterly winds south of latitude 35°. During this season also, the wind directions are found to be more variable at all stations. The increase in the average velocity of prevailing directions with latitude is especially pronounced during this season, varying from 6 or 7 m.p.s. over the extreme southern part of the country to 15 or 16 m.p.s. over the northern border. The advantage to air transport operations of flying a northern route east-bound and a southern route west-bound is particularly obvious during this season and at this level. The increase in wind velocity with height is not so pronounced during this season, however, as may be seen by comparing the 6 and 12 km. levels (Figs. 3 and 4). At most stations the increase is not more than 2 or 3 m.p.s. As far as the winds are concerned, therefore, very little advantage would be gained for air transportation by flying at any level greater than 6 km.

As may be expected, the wind conditions undergo a considerable change from summer to winter. This will be noted by inspecting Fig. 5 which shows the wind roses for the latter season at 6 km. First of all it will be noted that the prevailing directions are between W and WNW over the entire country with the percentage frequencies of these directions ranging between 30 and 35 percent at nearly all stations east of the Mississippi River. In general also, the average velocities are considerably higher than during the summer season. This is especially true over the southern portion of the country. Changes in prevailing directions between this season and the summer season are most marked over the far south and far west portions of the country. Examples of the changes in both the prevailing directions and the average velocities thereof may be seen in the wind roses for Groesbeck, Texas, and Redding, Calif. At Groesbeck the prevailing direction during the summer season at this level is NNE and the average velocity for that direction is 7 m.p.s., while during the winter season the corresponding values are W and 21 m.p.s. At Redding the prevailing direction at this level during the summer season is SW and the average velocity for that direction is 14 m.p.s., while during the winter season the corresponding values are NW and 19 m.p.s. During the winter season at these levels there is not such a marked change in the average velocities either with altitude or latitude but we have instead an apparent center of high velocities of 20 to 23 m.p.s. for the prevailing directions over the east-central portion of the country. At the next level (8 km., Fig. 6) a general increase in average velocities is found at all stations except those located over the north portion of the Rocky Mountain and Western Plateau region. The apparent absence of an increase in velocity with height between the 6 and 8 km. levels over the latter region may be due to the fact that the pilot balloon observations reach high levels, during this season, only when relatively low velocities prevail at all levels, or it may be due to the fact that, at this time of the year, this region lies in the path of frequent outbreaks of "polar" air masses from western Canada which bring down with them the characteristic conditions (including a low stratosphere) of the more northern latitudes. If the latter explanation is correct a cessation of the increase of velocity with height would be expected to be found at about 8 or 9 km., which corresponds to the average height of the base of the stratosphere for these latitudes during this season of the year.

It is not deemed necessary in this brief paper to discuss the wind roses for the spring and autumn seasons as they are primarily transition seasons between the extremes of summer and winter and the wind conditions during these seasons are therefore not greatly different from those for the year as a whole as shown in the annual charts.

As a part of this study the annual percentage frequencies from all 16 directions were combined into four quadrants with the four cardinal directions (N, E, S, and W) as the center of each quadrant. These data are shown for 10 representative stations in Table 1.

From this tabulation it may be seen that, on the average, westerly winds are predominant at nearly all levels and at all stations. Northerly winds are next in frequency with southerly winds next and easterly winds least frequent except at the southern stations of Due West, Jacksonville, Key West, New Orleans, Groesbeck, and Brownsville where easterly winds are more frequent than southerly winds. It is evident also that between 70 and 80 percent of the winds at all levels and for all stations are from the north and west quadrants. It appears, furthermore, that the annual percentage frequency of westerly winds reaches a maximum at an altitude of 5 or 6 km. except over the extreme south, southwest, and Pacific Coast sections of the country, where the frequency of westerly winds increases up to about 8 km. at most stations and up to 10 or 12 km. at others.

Resultant Winds

The *annual resultant* winds are shown in Fig. 7. These are based on the same records as are the wind roses. In computing resultants, each individual wind record is treated as a vector, wherein the vector is represented by an arrow whose length is proportional to the speed of the wind and whose direction is the same as that of the wind. The several vectors for all the observations are then combined into a single vector (by application of the well-known method of the parallelogram of forces), which represents the mass movement of

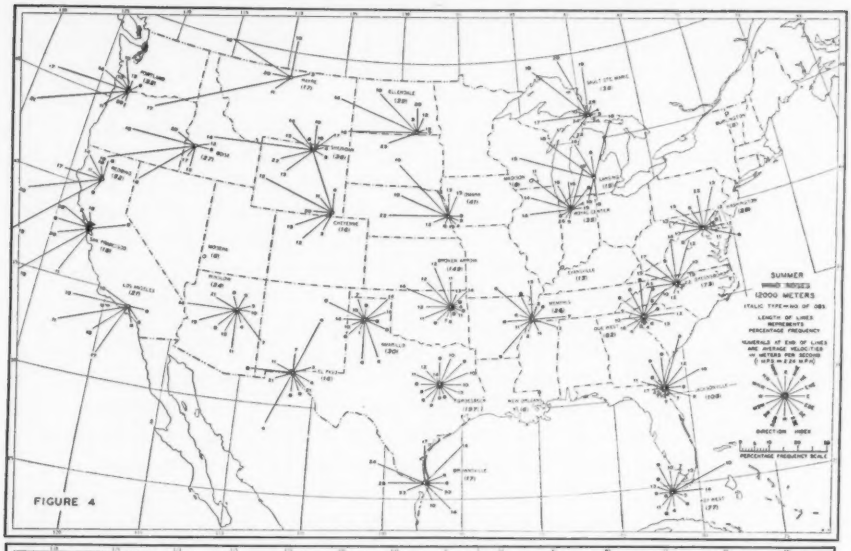
SUMMER
WIND ROSES
12000 METERS
ITALIC TYPE = NO. OF OBS.
LENGTH OF LINES REPRESENTS PERCENTAGE FREQUENCY
NUMERALS AT END OF LINES ARE AVERAGE VELOCITIES IN METERS PER SECOND
DIRECTION INDEX
PERCENTAGE FREQUENCY SCALE

FIGURE 4

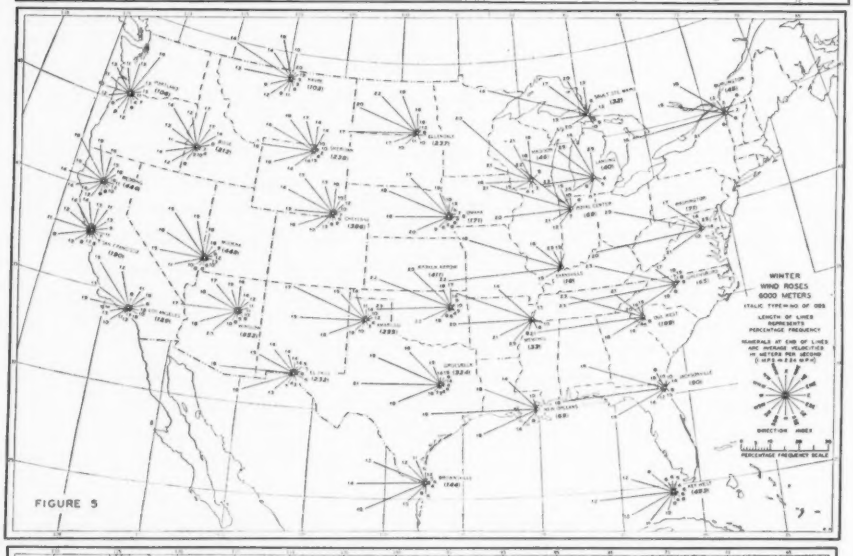
WINTER
WIND ROSES
6000 METERS
ITALIC TYPE = NO. OF OBS.
LENGTH OF LINES REPRESENTS PERCENTAGE FREQUENCY
NUMERALS AT END OF LINES ARE AVERAGE VELOCITIES IN METERS PER SECOND
DIRECTION INDEX
PERCENTAGE FREQUENCY SCALE

FIGURE 5

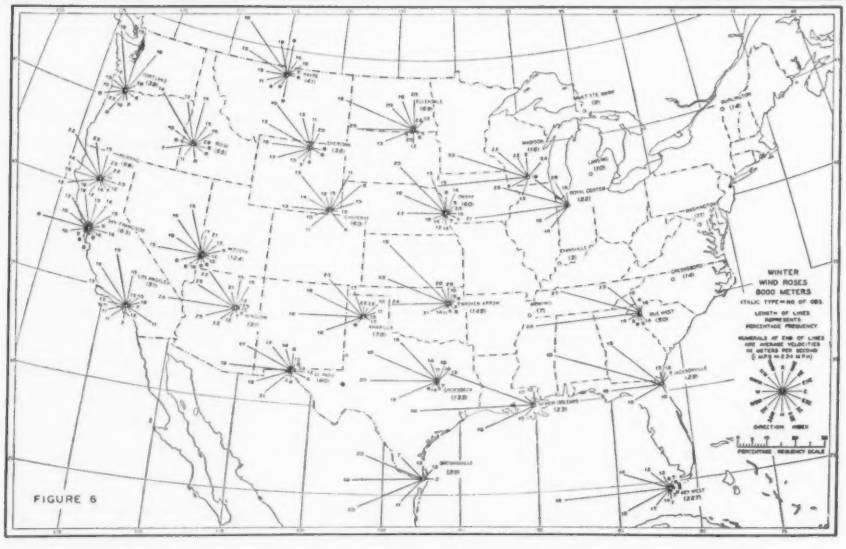
WINTER
WIND ROSES
8000 METERS
ITALIC TYPE = NO. OF OBS.
LENGTH OF LINES REPRESENTS PERCENTAGE FREQUENCY
NUMERALS AT END OF LINES ARE AVERAGE VELOCITIES IN METERS PER SECOND
DIRECTION INDEX
PERCENTAGE FREQUENCY SCALE

FIGURE 6

the air for the level and period involved. For example, a north wind of 12 m.p.s. when combined vectorially with a south wind of 8 m.p.s. will give a resultant north wind of 4 m.p.s. Resultant winds can be used to advantage for the planning of air-line schedules as they show the average wind factor which must be taken into account in flying over any particular route. It will be noted that for the year as a whole (Fig. 7), there is remarkably close agreement in both the direction and velocity of the resultant winds between levels and between adjoining stations. With a few exceptions, the annual directions fall between W and NW at all stations and all levels. The annual resultant velocities average about 10 m.p.s. over the northern part of the country, and decrease to about 6 m.p.s. over the extreme southern part. As in the case of the wind roses, the greatest variations from the annual values are found during the summer and winter seasons. Turning next to the summer season, (Fig. 8) therefore, it will be noted that relatively light velocities prevail over all sections of the country and at all levels except in the lower levels (6, 8, and 10 km.) over the northern part of the Rocky Mountain and Western Plateau region where they are, in general, greater than during the winter season (Fig. 9). This appears to be due to the fact that the base of the stratosphere is considerably higher during the summer season than during the winter season. It is to be expected therefore, that the increase in wind velocities with height would extend to a correspondingly higher altitude during the summer season. The resultant directions during the summer season are predominantly SW or WSW over the western Rocky Mountain and Pacific Coast regions and N or NE over the southeastern part of the country. This circulation, together with the light resultant velocities of less than 2 m.p.s. at Groesbeck, Texas, indicates the existence of a large high level anti-cyclone at these levels with its center located approximately over the state of Texas.

During the winter season (Fig. 9) a decided shift in the resultant directions toward the north will be noted. There is also a marked increase in resultant velocities at most stations, especially over the east-central part of the country where the average is approximately 16 m.p.s. at 6 and 8 km. Above 8 km. there appears to be little change in the resultant velocity over the northern part of the country but there is a continued increase up to the 12 km. level at least, over the southern part. For example, at Ellendale, North Dakota, the resultant velocity at 6 km. is 14.2 m.p.s. while at 10 km. it is 11.1 m.p.s. At Groesbeck, Texas, on the other hand, the corresponding values are 14.7 m.p.s. at 6 km. and 15.8 m.p.s. at 10 km.

Average Velocities

In Table 2, average velocities are shown for 9 representative stations, selected according to their geographical location. They are arranged in the table by categories of latitude from north to south and, within each category, from east to west across the country.

These values were obtained by dividing the sum of the velocities *for all directions* by the corresponding number of observations. In general, the variations of average velocity with height and with latitude are approximately the same as has been previously pointed out in the above discussion of wind roses and resultant winds.

Table 1

Annual Percentage Frequency of Wind Directions by Quadrants

North winds include—NNW, N, NNE, and ½ (NW + NE).
East winds include—ENE, E, ESE, and ½ (NE + SE).
South winds include—SSE, S, SSW, and ½ (SE + SW).
West winds include—WSW, W, WNW, and ½ (SW + NW).

Station	Quadrant	6 Km.	8 Km.	10 Km.	12 Km.	14 Km.
Washington, D. C.	N	24	26	28	34	*
	E	4	6	6	14	
	S	5	7	12	6	
	W	67	61	54	46	
Madison, Wis.	N	32	35	43	34	*
	E	5	6	10	27	
	S	6	8	7	5	
	W	57	51	40	34	
Havre, Mont.	N	18	23	31	17	*
	E	2	3	7	13	
	S	12	11	12	10	
	W	68	63	50	60	
Due West, S. C.	N	21	24	26	35	33
	E	9	9	12	18	25
	S	8	7	10	5	14
	W	62	60	52	42	28
Amarillo, Texas	N	27	28	27	17	*
	E	10	13	15	15	
	S	13	13	17	21	
	W	50	46	41	47	
Key West, Fla.	N	17	20	23	30	36
	E	20	18	20	19	19
	S	17	14	10	9	15
	W	46	48	47	42	30
Brownsville, Texas	N	23	25	31	25	*
	E	20	18	15	16	
	S	13	11	10	8	
	W	44	45	43	51	
El Paso, Texas	N	19	18	20	24	*
	E	11	9	10	9	
	S	16	14	13	13	
	W	54	59	57	54	
Los Angeles, Calif.	N	24	27	23	17	*
	E	11	9	6	6	
	S	23	17	19	16	
	W	42	47	52	61	
Redding, Calif.	N	25	25	26	23	27
	E	7	8	9	9	3
	S	22	18	19	17	20
	W	46	49	46	51	50

* Not computed—less than 15 observations.

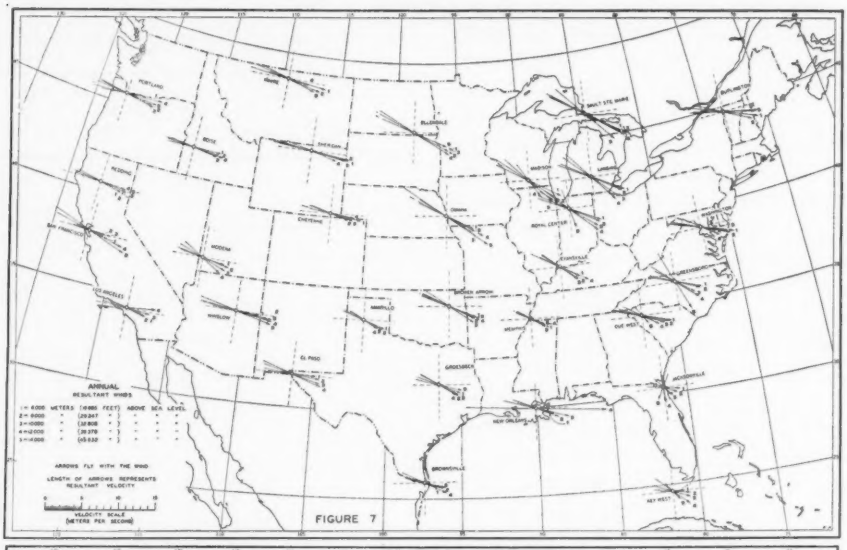

FIGURE 7

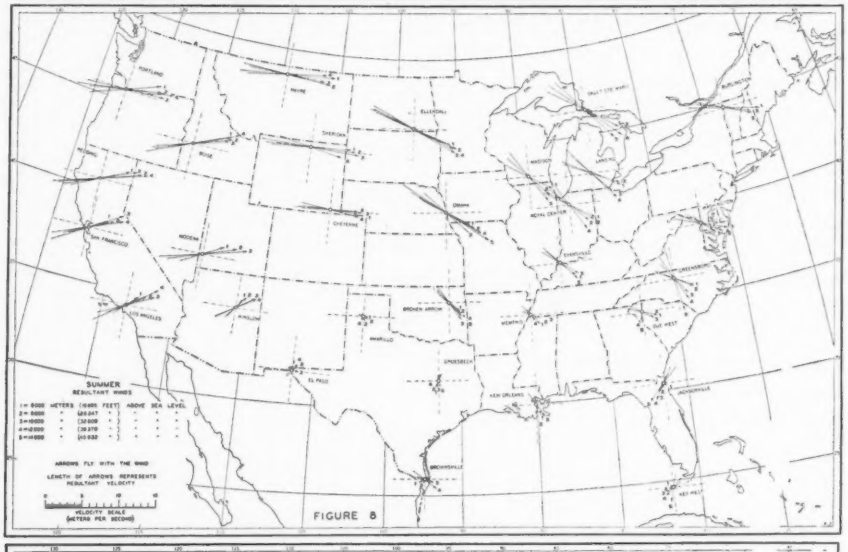

FIGURE 8

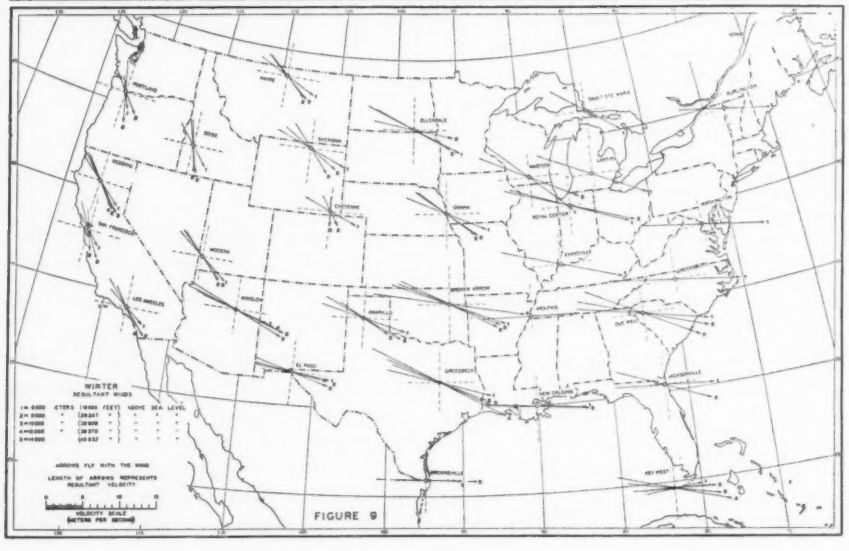

FIGURE 9

TABLE 2

Average Wind Velocities (in Meters per Second) for a Selected Group of Stations

	Altitude (Meters)	Winter	Spring	Summer	Autumn	Annual
Royal Center, Ind.	6,000	19.5	13.3	10.7	13.2	12.5
	8,000	21.6	13.7	12.0	14.3	13.4
	10,000	*	14.7	13.5	15.6	14.7
	12,000	*	15.6	13.7	13.9	14.3
	14,000	*	*	*	*	10.8
Ellendale, N. Dak.	6,000	17.9	15.5	13.6	15.8	15.2
	8,000	16.5	15.8	16.4	16.2	16.2
	10,000	14.6	13.4	17.3	16.5	16.0
	12,000	*	14.0	16.1	15.6	15.4
	14,000	*	*	*	*	13.8
Portland, Ore.	6,000	12.2	12.1	13.0	12.3	12.6
	8,000	14.4	14.1	13.5	12.4	13.5
	10,000	14.8	15.6	14.0	10.7	13.8
	12,000	*	12.2	16.2	9.8	13.4
	14,000	*	*	*	*	14.0
Due West, S. C.	6,000	20.3	13.4	7.7	11.2	11.4
	8,000	20.9	11.7	8.4	11.8	11.0
	10,000	20.0	11.4	8.9	13.0	11.3
	12,000	*	11.6	9.4	14.7	12.1
	14,000	*	*	8.4	*	9.2
Omaha, Nebr.	6,000	15.6	12.2	9.9	12.7	11.7
	8,000	16.4	13.9	11.8	12.7	12.7
	10,000	16.6	15.1	12.8	13.9	13.7
	12,000	*	*	16.0	16.1	16.2
	14,000	*	*	17.4	*	17.8
San Francisco, Calif.	6,000	11.3	10.4	8.8	10.3	10.0
	8,000	12.0	9.4	11.0	10.5	10.7
	10,000	13.8	10.0	13.9	12.8	12.9
	12,000	*	*	14.8	16.8	15.6
	14,000	*	*	*	15.6	15.2
Key West, Fla.	6,000	10.5	10.0	5.1	6.6	7.7
	8,000	14.0	13.8	6.0	9.2	9.9
	10,000	15.8	14.8	8.7	11.4	11.6
	12,000	19.6	15.6	9.3	12.9	12.8
	14,000	*	*	10.2	10.7	11.2
Groesbeck, Texas	6,000	17.8	14.7	6.2	10.2	10.7
	8,000	18.1	15.8	7.1	12.1	11.2
	10,000	20.4	15.7	8.6	14.2	12.0
	12,000	25.2	13.1	9.4	16.6	12.8
	14,000	*	*	9.4	18.3	13.0
Los Angeles, Calif.	6,000	12.8	10.7	7.4	10.0	9.9
	8,000	12.8	11.7	9.4	11.6	11.1
	10,000	14.4	10.2	11.5	11.4	11.7
	12,000	*	*	12.6	11.2	11.4
	14,000	*	*	*	*	*

* Not computed—less than 15 observations.

The annual average velocities increase with latitude from south to north approximately as follows: 8 to 15 m.p.s. at 6 km., 10 to 16 m.p.s. at 8 km., 11 to 16 m.p.s. at 10 km., and 13 to 15 m.p.s. at 12 km. At 14 km. the data are insufficient to indicate the latitudinal trend accurately at that level. During the winter season, however, there appears to be no regular change in velocity with latitude but instead, a concentration of high velocities over the east-central portion of the country, the average being 21 or 22 m.p.s. at 8 km. Above 8 km. the number of observations available for this season are not sufficient to locate the area of high velocities accurately, but it appears to shift toward the southern Great Plains with altitude, the highest average velocities at 12 km. being 25.2 m.p.s. at Groesbeck and 23.8 m.p.s. at Broken Arrow. This season is also characterized by decreasing average velocities with height above 6 km., over the northern part of the Rocky Mountain and Western Plateau regions as previously pointed out. This is shown by the records for Ellendale, Havre, Boise, Sheridan, and Cheyenne, the combined average for the five stations being 14.4, 13.1, and 11.9 m.p.s. for 6, 8, and 10 km., respectively. Except over the region just mentioned, average velocities are highest during the winter season and lowest during the summer season, the seasonal range being greatest over the southern part of the country.

TABLE 3

Annual total (all directions combined) *percentage* frequencies of velocities of 22–27 m.p.s., 28–36 m.p.s. and over 36 m.p.s., respectively, for the northern (north of latitude 41°), central (between latitudes 35° and 41°) and southern (between latitudes 24° and 35°) sections of the country.

	6,000 Meters			8,000 Meters			10,000 Meters		
Section	22–27	28–36	over 36	22–27	28–36	over 36	22–27	28–36	over 36
Northern	8.3	2.8	0.5	10.4	3.5	0.7	10.5	5.0	0.8
Central	5.8	2.6	0.6	7.2	2.6	0.8	8.4	4.2	1.3
Southern	5.1	2.6	0.7	5.5	3.0	0.8	8.0	3.4	1.1

FREQUENCY OF HIGH VELOCITIES

In this study tables were prepared showing the percentage frequency of the occurrence of high wind velocities of 22 to 27 m.p.s. (48–60 m.p.h.), 28 to 36 m.p.s. (61–80 m.p.h.) and over 36 m.p.s. (80 m.p.h.), respectively, for the first three levels (6, 8, and 10 km.). This was done for all stations by seasons and for each wind direction. The total (all directions combined) annual values for the northern, central, and southern sections of the country, respectively, as obtained from the original tabulation, are shown in Table 3.

The original tabulation of these data shows that high velocities occur most frequently with westerly winds. Over the western Rocky Mountain and Pacific Coast regions, however, they also occur consistently with directions between N and E, especially during the winter months. In general, there is a decided seasonal variation in the frequency of high velocities at these levels, the maximum occurring during the winter season and the minimum during the summer season at all stations. Over the east central part of the country, for example, the frequency of velocities of 22 to 27 m.p.s. (48–60 m.p.h.) at 6 km. varies from 21 to 27 percent during the

winter season and from 1 to 5 percent during the summer season. Most stations show an increase in frequency of high velocities between 6 and 10 km. during all seasons. This is more pronounced in summer than in winter. From Table 3 it will be seen that the frequency of high velocities, for the year as a whole, increases with altitude for all three velocity groups but with latitude for only the first two velocity groups, velocities of over 36 m.p.s. (80 m.p.h.) increasing in frequency from north to south at all three levels.

Extreme Velocities

The final step in this summary was the tabulation of extreme (highest on record) velocities for all Weather Bureau pilot balloon stations (a total of 97) both active and discontinued, and for all records through July, 1936. An analysis of these records reveals the fact that winds of 40 m.p.s. (90 m.p.h.) or over have been recorded at these levels, at least once during the past several years, at 66 different stations. Winds of 50 m.p.s. (112 m.p.h.) or over have been recorded at 30 different stations and winds of 60 m.p.s. (134 m.p.h.) or over have been recorded at 9 different stations. All of these groups of stations are well distributed over the country, indicating that the occasional occurrence of very high velocities at these levels is not confined to any particular section of the country. In most cases, however, these records were restricted to the three lower levels (6, 8, and 10 km.). The highest recorded velocity for all stations was 81 m.p.s. (180 m.p.h.) from the NW at 6 km. at Lansing, Michigan, on the morning of December 17, 1919. Although this was a *single-theodolite* observation, in which the ascensional rate of the balloon was assumed rather than measured; an examination of the original record as well as those made at other stations at approximately the same time, gives no reason to doubt its accuracy. It is verified to some extent also by the unusually rapid movement of a surface high pressure area of 30.50 in. which was centered at St. Paul, Minn., on the morning of this observation and 24 hrs. later was centered at Philadelphia, Pa., approximately 1000 miles away.

On the Distribution of Lift Across the Span Near and Beyond the Stall

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(Received January 15, 1937)

Summary

AT HIGH angles of incidence near or beyond the point where the lift has a maximum value the distribution of lift across the span of a wing differs considerably from that at low angles of incidence. This is due to the fact that the condition $C_L = \text{const.} \cdot \alpha$ which is fulfilled at low angles of incidence does not hold at angles of incidence near or beyond the stall. Most of the known methods for calculating the lift distribution are based on this condition and cannot be applied to the case of a lift curve of arbitrary shape. Therefore an approximate method was used in calculating the distribution of lift near and beyond the stall for two aerofoils. The induced velocity is used in determining the regions of stalled and unstalled flow.

Introduction

In comparing lift distributions across the span calculated on the assumption $C_L = \text{const.} \cdot \alpha$ (*i.e.*, constant slope of the lift curve) with experimental results the following facts are noted: At low angles of incidence the agreement between calculated and measured distribution is in most cases fairly close, with the exception of a small region near the wing tips where local discrepancies can be observed in some cases. At angles of incidence near and beyond the stall, however, a very noticable difference between calculation and experiment can be observed. The lift is shifting toward the wing tips and sometimes the local lift coefficient shows a higher value near the wing tips than at the center of the wing.

The discrepancy between the lift distribution near the stall found by calculation and by experiment is due to the breaking down of the basic theoretical assumptions.

It is a well-established fact that the lift reaches a maximum value at the critical angle and then decreases with increasing angle of incidence. The slope of the lift curve is, therefore, not constant; it is positive below stalling, zero at the stalling point and negative beyond the stall. If the lift distribution is calculated for a rectangular wing assuming various values of the slope (in each case this value is assumed to be constant) it is found that with decreasing value of the slope the lift concentrates more toward the wing tips, and in the hypothetical case where $dC_L/d\alpha = 0$ for a finite range, the lift distribution is found to be uniform along the span. For an infinitely small range this condition is realized at the stalling point and therefore a distribution tending to a uniform distribution is to be expected. For a given value of total lift the bending moment with reference to the wing root in this latter case is higher than that of a wing with elliptical distribution. Therefore the actual shape of the lift distribution is important for calculating the bending stresses of the spars. With the knowledge of the distribution of lift and induced velocities across the span, regions of stalled and unstalled flow can be determined. This is of importance for judging the effect of the ailerons. Some investigations on these lines were carried out by G.V. Lachmann[1] who has worked out the lift distribution of a wing in semi-stalled condition by means of a graphical approximation which, however, is rather cumbersome.

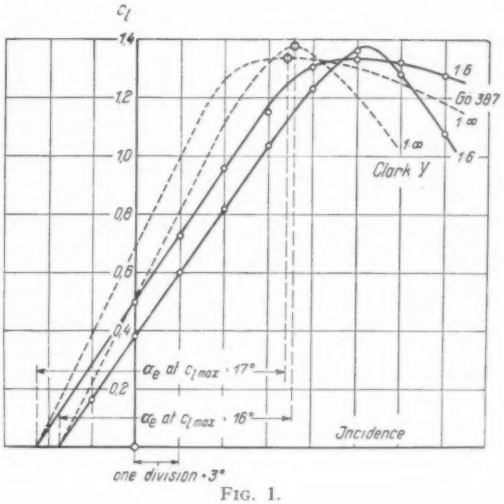

FIG. 1.

Results

This report deals with the results of calculations of the lift distribution which are based on the actual lift curve of the wing section under consideration. Two rectangular wings with an aspect ratio of 6 were investigated having Clark Y and Göttingen 387 sections. The lift curve of the Clark Y section shows a rather pointed maximum in comparison with the Göttingen 387 which has a flat top C_L curve. Fig. 1 represents the lift coefficients of the two sections as a function of the angle of incidence according to results obtained in the

[1] G. V. Lachmann, *Control Beyond the Stall*, Journal of the Royal Aeronautical Society, Vol. 36, No. 256, page 276, April, 1932.

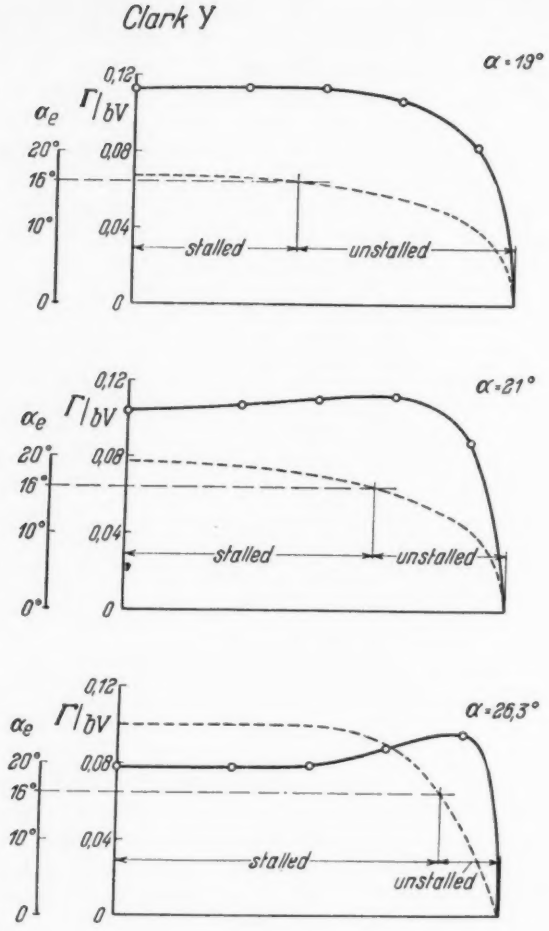

FIG. 2.

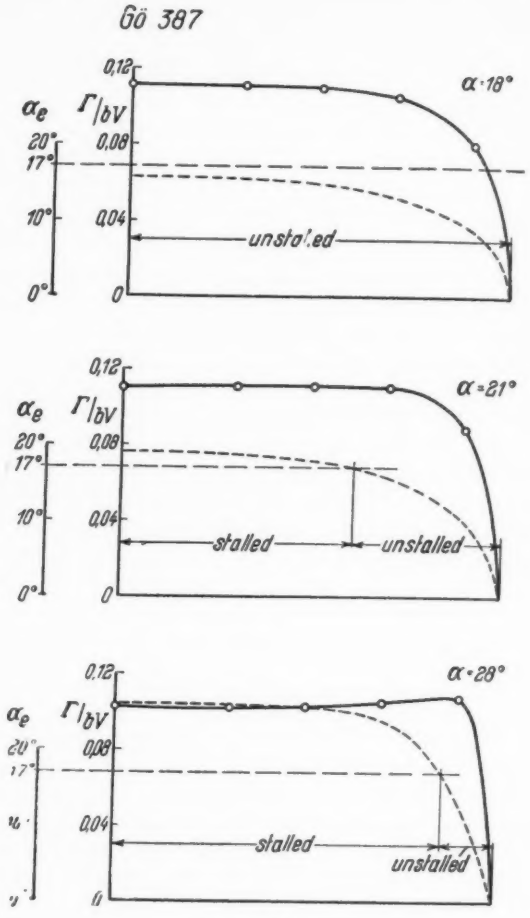

FIG. 3.

compressed wind tunnel at Langley Field at Reynolds Numbers of 3.61×10^6 and 3.47×10^6, respectively.[2] The full lines correspond to an aspect ratio of 6, the dotted lines are corrected for infinite span by using Glauerts' formulae. This way is actually not correct as these formulae are also based on the assumption that $C_L = \text{const.} \cdot \alpha$ which does not hold near and beyond the stall. The best way would be to test the section under consideration in a pure two dimensional flow. It is assumed that the dotted lines in Fig. 1 are the results of such tests. For the sake of simplicity the angles of incidence are measured from the zero lift position. The method used for calculating the lift distribution is briefly as follows:

Most of the methods used for calculating the lift distribution are based on the assumption that $C_L = \text{const.} \cdot \alpha$ and, therefore, break down when angles of incidence near or beyond the stall are considered. In such a case, however, a method developed by J. Tani[3] can be applied. This method, which is perhaps less accurate but very much simpler than most of the other methods, can be used for calculating the lift distribution at any angle of incidence. The distribution is worked out by a process of successive approximations. One starts with a reasonably assumed lift distribution and calculates by a very simple process the corresponding induced velocity and the effective angle of incidence. Now, with the help of the lift curve for infinite aspect one works back to a new lift distribution. This distribution will not agree with the assumed distribution. Therefore mean values are adopted and the process is continued until the agreement is satisfactory. Under normal circumstances from three to four approximations give a fairly good result. The numerical calculations are very simple as no systems of equations must be solved. In the case under consideration the lift was calculated at five points along the semi-span. The distances y of these points from the center line expressed in fractions of the semi-span were:

$$y = 0 \quad y = 0.3 \quad y = 0.5 \quad y = 0.7 \quad y = 0.9$$

The results of the calculations for the two wings are rep-

[2] See N.A.C.A. Technical Note No. 219.

[3] J. Tani, *A Simple Method of Calculating the Induced Velocity of a Monoplane Wing*, Report No. 111 of the Aeronautical Research Institute of Tokyo Imperial University.

TABLE 1

Clark Y Section

	$\alpha = 19°$			$\alpha = 21°$			$\alpha = 26.3°$		
	Fifth Approximation			Third Approximation			Third Approximation		
	Γ/bV		α_e	Γ/bV		α_e	Γ/bV		α_e
y	Assumed	Calculated		Assumed	Calculated		Assumed	Calculated	
0	0.113	0.113	16.7°	0.104	0.104	19.4°	0.078	0.079	25.0°
0.3	0.113	0.114	16.5	0.107	0.107	18.7	0.078	0.079	25.0
0.5	0.113	0.114	15.5	0.110	0.110	17.8	0.079	0.079	25.1
0.7	0.107	0.107	13.8	0.112	0.113	15.2	0.088	0.087	22.9
0.9	0.083	0.083	10.1	0.088	0.087	10.6	0.096	0.096	11.7

Göttingen 387 Section

	$\alpha = 18°$			$\alpha = 21°$			$\alpha = 28°$		
	Third Approximation			Second Approximation			Third Approximation		
	Γ/bV		α_e	Γ/bV		α_e	Γ/bV		α_e
y	Assumed	Calculated		Assumed	Calculated		Assumed	Calculated	
0	0.111	0.111	15.8°	0.110	0.110	18.9°	0.102	0.102	26.1°
0.3	0.111	0.111	15.3	0.111	0.111	18.5	0.102	0.102	26.1
0.5	0.110	0.110	14.7	0.111	0.111	17.8	0.103	0.103	25.5
0.7	0.105	0.105	13.0	0.110	0.110	15.8	0.105	0.105	24.1
0.9	0.080	0.075	8.8	0.089	0.088	10.4	0.107	0.106	13.1

resented in Figs. 2 and 3. For the Clark Y section the calculations were performed for geometrical angles of incidence (measured from the position zero lift) of $\alpha = 19°$, 21°, and 26.3°. The angles for the Göttingen 387 section were $\alpha = 18°$, 21°, and 28°. The lowest angle of incidence corresponds to a lift value just below the maximum lift. The second angle is chosen at the maximum lift and the highest angle beyond the stall, where the lift decreases with increasing angle of incidence. In Figs. 2 and 3 the value Γ/bV (Γ = circulation, b = span) is plotted across the span (full line). The shape of this distribution differs considerably from the usual shape at low angles of incidence. Of particular interest is the distribution for a stalled wing where the lift near the wing tips is higher than at the central portion of the wing. The general type of this distribution is in agreement with the results of wind-tunnel tests.

Figs. 2 and 3 show also the value of the effective angle of incidence along the span (dotted line). Since the effective angle of incidence at which the flow breaks away (stalling angle) is known, the boundary between stalled and unstalled flow can easily be determined. For instance the Clark Y section has an effective stalling angle of 16°. Therefore at points where the effective angle α_e is higher than 16°, the flow is stalled; over the remaining part of the span ($\alpha_e < 16°$), the flow is unstalled. It is interesting to note that even at geometrical angles of incidence beyond the stall a small region of unstalled flow near the wing tips still exists. This result is of practical importance for investigations concerning the effect of the ailerons. Table 1 contains, for the final approximation (the number of which is indicated) the assumed distribution Γ/bV and the calculated distribution. One sees that the agreement is fairly close. Under normal conditions three approximations are sufficient; in only one case have five approximations been necessary.

Forecasting the Dissipation of Fog and Stratus Clouds

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Presented at the Meteorology Session, Fifth Annual Meeting, I. Ae. S.
January 28, 1937

Introduction

FORECASTING the time at which fog or stratus clouds will break has become a particularly important problem in recent years with the development of commercial and military aviation and the improved methods of flying which have resulted. Many times the completion of an airline schedule is dependent upon the dissipation of a fog or low cloud deck within a given time. Even the rate at which the ceiling is rising becomes important, for may flights could be dispatched toward fog-bound terminals without long delays if a definite indication of sufficient improvement were available.

At present, forecasts involving these elements are largely a function of the forecaster's experience, and are not always extremely accurate or reliable. Various empirical methods employing such elements as the thickness of the cloud, the height of the cloud base, and the fact that terrestrial radiation is completely absorbed by the lower levels of the clouds, appear to have formed the principal aids to forecasting the breaking of fog and stratus systems. The absorption of terrestrial radiation has been generally credited as the source of heat providing for the dissipation of a cloud, since the process normally takes place upward from the cloud base. A moment's thought will convince one that this factor cannot be of very great importance. Brunt[1] has shown that the radiative transfer of heat in the atmosphere in regions of the spectrum where water vapor is the effective absorbing agent, is negligible. This means that any net gain of heat at a cloud base by radiation must originate in the transparent regions of the spectrum, a series of bands accounting for only about 25% of the total. This gain is further reduced by the fact that a cloud acts as a black body, and therefore the sky radiation on a cloudy day cannot differ greatly from that originating at the earth's surface, especially if the cloud is low and its temperature nearly the same as that of the ground beneath. Hence, it seems illogical to assume that cloud decks several thousand feet in thickness may be dissipated within a few hours by heat gained from the absorption of terrestrial radiation.

It would appear that a much more powerful mechanism by which heat may be conveyed to the cloud layer must be sought. The transport of heat from surface levels to the cloud by convective turbulence offers a solution and forms the thesis for the present discussion. The use of this concept in attempting to devise a method for predicting the breaking time of fog and stratus is suggested by a paper of Petterssen[2] in which he notes the convective nature of the California fogs. The effective transport of heat in the atmosphere by this mechanism is well known and need not be discussed here.

Physical Aspects of Fog and Stratus Dissipation

If it is assumed that convective turbulence provides the mechanism for the transport of surface heat to the cloud base, it must be assumed that during the daytime at least, the cloud is maintained by convection. This means that the temperature lapse rate below the cloud base must be approximately the dry adiabatic and that within the cloud layer the saturation adiabatic. In Fig. 1 the curve *xyz* gives a typical upper-air structure, as reported from a sounding through a stratus cloud system. These data have been plotted on an ordinary adiabatic chart including temperatures as abscissae, pressures as ordinates, dry and moist adiabats, and specific humidity curves at saturation. The points *x* and *y* are usually the only two reported from the surface up to the base of the inversion *yz*. The slope of *xy*, as indicated in Fig. 1, is normally a little less than that of a dry adiabat. It would have been more exact if reported as the curve *xwy*, where *xw*, the portion below the cloud base, has the slope of a dry adiabat, and *wy*, the portion within the cloud, that of a moist adiabat. The point *w* is seldom reported in an aerological sounding, since the inflection in the temperature curve at this level is slight. However, for the present discussion, *w* becomes very important and must be located. It may be determined graphically on an adiabatic chart by following either a saturation adiabat from *y* to the cloud base or a dry adiabat from *x* to the cloud base. When there is disagreement, the former construction is preferable since the temperature at the cloud top is usually more reliable than that at the ground. The broken lines *yw* and *xw* in Fig. 1 illustrate this construction. Theoretically *w*, which it will be

[1] D. Brunt, *Physical and Dynamical Meteorology*, page 117; Macmillan & Company, New York, 1935.

[2] Sverre Petterssen, *On the Causes and the Forecasting of the California Fog*, Journal of the Aeronautical Sciences, Vol. 3, No. 9, July, 1936.

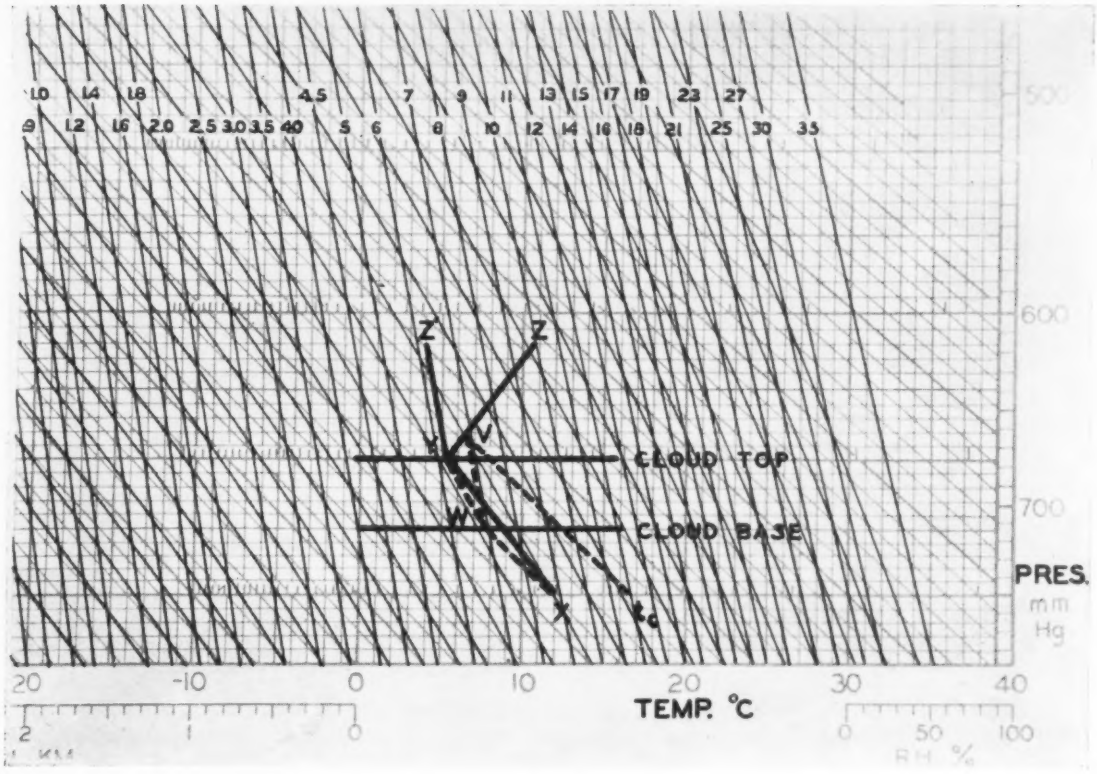

FIG. 1.

noted marks the condensation level, should lie on the specific humidity curve corresponding to the surface value, since this element is conservative during the dry stage of adiabatic convection.

The location of w by the above method entirely eliminates the use of humidity data from aerological soundings in preparing forecasts of this nature. This is desirable since the measurement of this element is rather uncertain, yet fog and clouds are extremely sensitive to small humidity variations. In locating w, it has merely been assumed that the cloudy air is at saturation, a reasonable supposition in the case of fog and low stratus formations.

As the fraction of solar radiation not reflected from the cloud top becomes effective in raising the ground temperature, w will rise along the saturation specific humidity curve passing through it (wv in Fig. 1). This is necessitated by the convective maintenance of an adiabatic lapse rate under the cloud base and the constancy of the specific humidity at the ground. The cloud base must rise at the same rate, since w coincides with the condensation level.

If surface heating continues until the temperature reaches the value t_c, w, the condensation level, will coincide with v, the base of the inversion vz. Further surface heating will eliminate the possibility of cloud formation since convection must cease at the base of the inversion, which will then lie below w. Therefore t_c may be regarded as a critical surface temperature which, if exceeded, will fail to maintain a cloud deck.

The time at which a cloud layer breaks is thus a function of the temperature difference $t_c - x$. Before discussing a method for determining the time required for the surface temperature to rise an amount $t_c - x$, it is appropriate to indicate the factors governing the value of t_c.

t_c has a unique solution as long as the upper air structure above the cloud remains unchanged, and therefore may be computed for a given situation once and for all from a sounding made at any time of the day. From Fig. 1 it may be noted that the value of t_c is primarily a function of the lapse rate above the cloud. It is finite for lapse rates less than that indicated by the line yz', which is parallel to wv, infinite for this value and imaginary for greater values. Since during the convective process, air reaching the cloud base will continue to rise along a saturation adiabat until it attains the temperature of its environment, this is equivalent to saying that the cloud base rises faster than the cloud top when t_c is finite, at the same rate when t_c is infinite, and more slowly when t_c is imaginary. Since the value of t_c must obviously lie below the diurnal maximum in order to break the cloud, the presence of a rather marked inversion above the cloud is normally required. In the case of cloud layers of appreciable thickness, an isothermal structure or

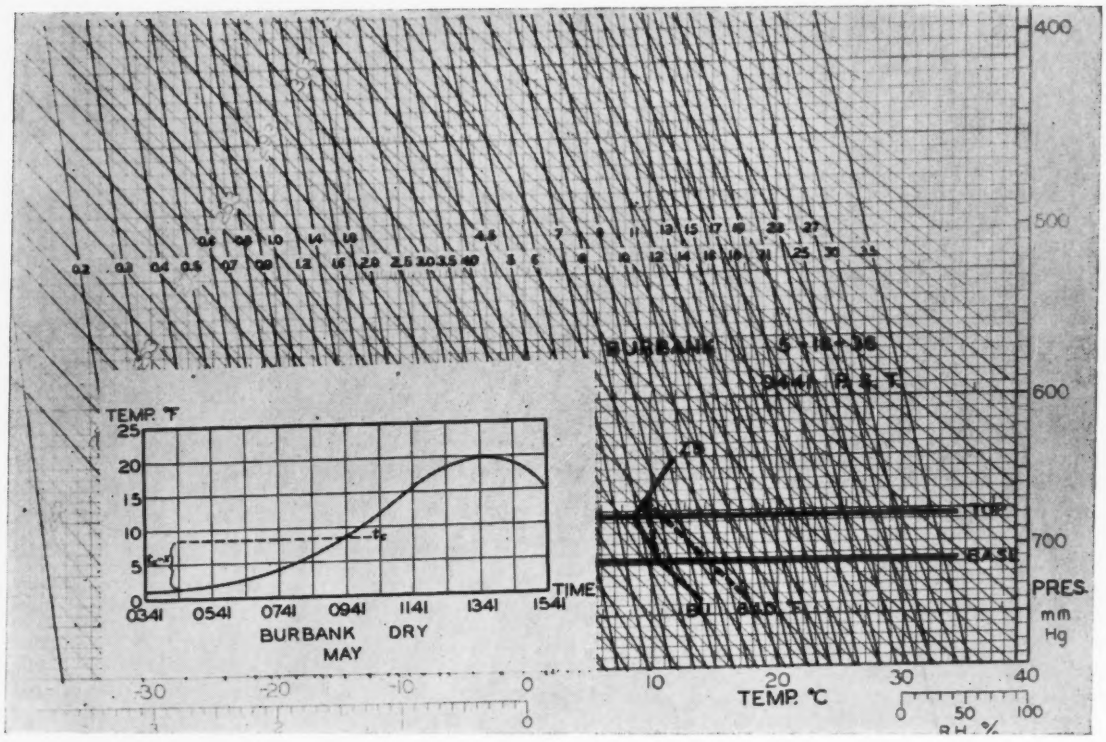

FIG. 2.

even a weak inversion usually yields too large a value of t_c to insure breaking.

Fig. 1 may be used to illustrate the dissipation of a layer of fog as well as a cloud deck by simply considering that the cloud base rests upon the earth's surface. It will be seen that the rise in temperature at the surface necessary to dispell a fog layer of this thickness is exactly the same as in the case of the similar cloud deck. Normally fogs are much thinner than cloud decks and therefore yield a smaller value of $t_c - x$, other things being equal. This accounts for the fact that they normally break much sooner than do cloud decks.

Many times, in airline operation, the mere lifting of a cloud base a few hundred feet will enable a pilot to negotiate a safe landing. The method outlined above may be used to anticipate the rate at which a cloud base will rise, just as effectively as the time at which the cloud will break. Both forecasts resolve themselves to simply anticipating the time at which a critical surface temperature will be reached.[3] For this purpose it has been found convenient to plot monthly mean diurnal temperature curves for overcast skies at locations for which forecasts are to be prepared. Relative values of temperature are used since the absolute values vary from day to day, while the general shape of the curves remains unchanged. It is useful to prepare separate curves at inland stations for dry ground and for moist ground. At coastal stations rather moist conditions prevail, and one curve is sufficient. It should be noted at this point that evaporation will retard the rise in temperature at the ground when it is moist. However, it is taken care of in the construction of the diurnal temperature curves. Any appreciable evaporation would have the added effect of increasing the specific humidity at the ground and thus increasing the value of t_c slightly. It is well to bear this in mind and to regard the time at which the critical temperature is reached, under these conditions, as a minimum.

After the value $t_c - x$, for the time of breaking or for the establishment of a given ceiling, has been found from an adiabatic chart, the appropriate diurnal curve is used to determine the time at which the desired

[3] There are several factors governing the time required for the surface temperature to rise an amount $t_c - x$. It will depend upon the soil constants, density, ρ_E, specific heat, c_E, and thermal diffusivity, k_E, and the net incoming radiation, R_n. Of these factors, the soil constants are the more important, since they vary with location and the condition of the soil, while for a given time of year R_n is relatively constant. An approximate expression for the time, t, for a rise of the surface temperature, $t_c - x$, is given by

$$t = \frac{(t_c - x)^2 \rho_E^2 c_E^2 k_E}{R_n^2}$$

Due to the variation of the soil constants at different locations under varying weather conditions, it is impractical to use this expression in forecasting, and the method outlined above has been found an effective substitute.

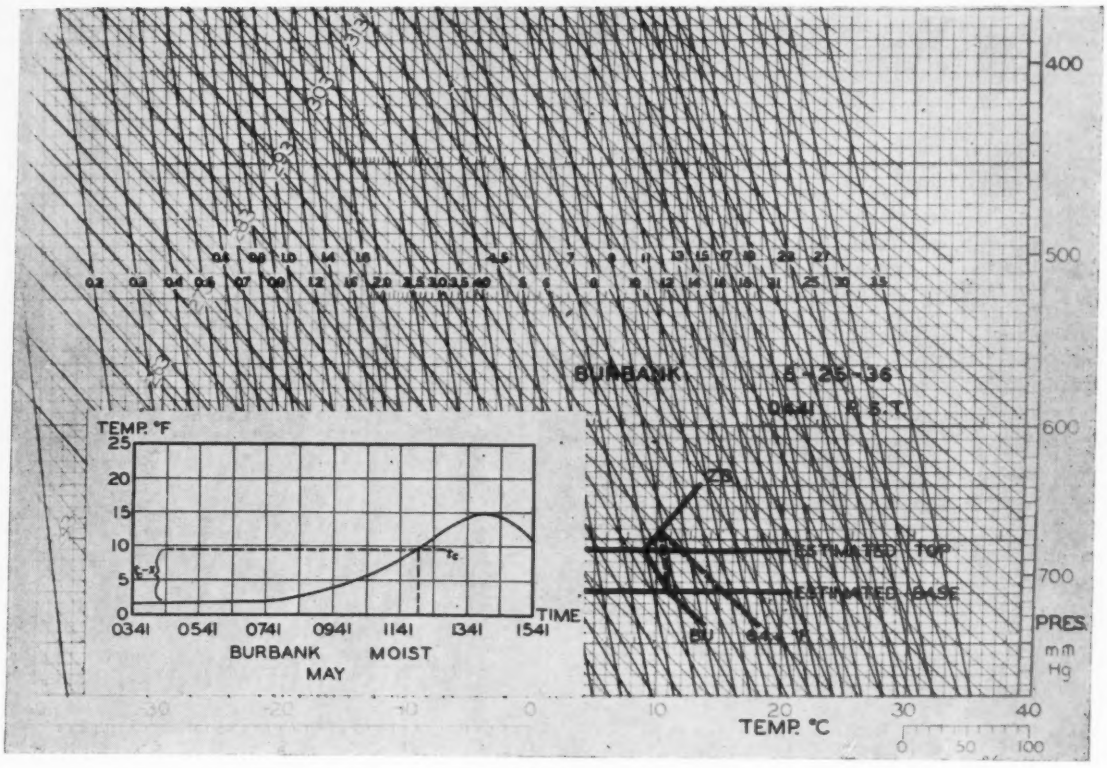

FIG. 3.

condition will be attained. The procedure will be indicated below in illustrative examples.

The above discussion seems rather lengthy, but in practice the procedure in preparing a forecast will be found extremely simple. The method is not limited to local application but may be used anywhere, provided the synoptic situation does not indicate any rapid change in the upper air structure and no superincumbent cloud layers are present. It is just as effective over the ocean as at coastal or inland stations.

In airline work, it is unnecessary to delay the preparation of a forecast until the reception of regular aerological flight data normally available only from a limited number of stations. Pilots leaving the airport ordinarily report the base and top of a cloud deck, together with air temperatures at intervals during their climb. From these data and the surface temperature, the meteorologist may readily determine the value of t_c on an adiabatic chart. By starting with the surface temperature and following a dry adiabat to the reported cloud base and a moist adiabat to the cloud top, the temperature at the cloud top is obtained. This may not coincide with the temperature reported at that point by the pilot due to a lag or an inaccuracy in his thermometer. Although inaccuracies in the reported temperatures above the cloud top may occur, the slope of the temperature height curve, which is the important thing for a determination of t_c, is unaffected and may be fitted to the curve constructed from the surface to the cloud top. This curve completed, t_c may be readily found in the manner outlined above.

EXAMPLES OF THE USE OF THE METHOD IN FORECASTING

Several examples of the use of the method in Southern California will serve as an illustration of the accuracy to be expected. In certain locations, a determination of t_c is possible without aerological data. Fig. 2 gives an example of such a calculation at Union Air Terminal, Burbank, California, for observations reported at 4:41 a.m. PST, May 18, 1936. The cloud top was reported by a pilot near the time of observation and the cloud base determined from a ceiling measurement by the Weather Bureau station at the airport. With this information and the surface temperature, the temperature at the cloud top was determined by the method outlined in the preceding paragraph. The approximate lapse rate above the clouds was found by joining the temperature at the cloud top with the 4:41 a.m. report of surface temperature from a mountain observatory of known elevation in the vicinity (ZB). From the previous day's sounding and the synoptic charts, it was apparent that this station lay well within a temperature inversion above the clouds, therefore justifying the construction. A critical temperature of 64°F. was determined in the prescribed manner, as indicated by the broken lines in Fig. 2. It is convenient to express t_c in degrees Fahrenheit in checking against subsequent teletype observations, reported to the

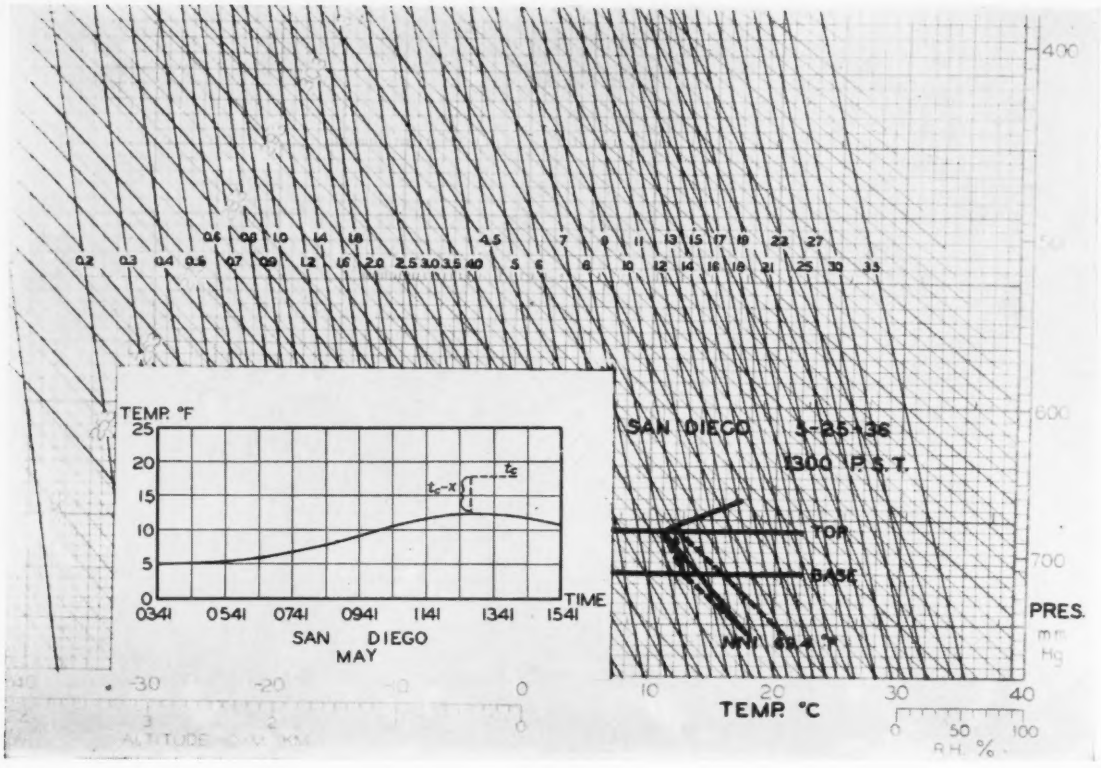

FIG. 4.

nearest °F. along the airways. The surface temperature at Burbank at the time of observation, 4:41 a.m., was 57°F. Thus at 4:41 a.m., the value of $t_c - x$ was 7°F. In order to determine the time at which the clouds will clear, it is necessary to ascertain the time required for an increase of 7°F. in the surface temperature. On the preceding night, no mist or drizzle was reported, so that the diurnal curve for dry soil was used. The construction on this curve (included in Fig. 2) is self-explanatory and indicates that the clouds should be clearing at the 9:41 a.m. observation. The fact that the clouds did begin to clear at about this time and at the computed critical temperature is brought out by the following sequence of reports from Burbank on this morning:

BURBANK 5-18-36

Time	Ceiling Ft.	Sky Condition	Temperature °F	Remarks
6:41	1700	overcast	58	
7:41	1800	overcast	59	thin spots
8:41	2000 (est.)	overcast	62	breaks
9:41	2200 (est.)	broken clouds	64	
10:41	unlimited	clear	66	few stratus

Although breaks in the overcast were reported 2°F. below the critical temperature, no appreciable clearing occurred until the critical temperature had been reached as evidenced by the complete clearing within one hour after the surface temperature reached 64°F., as compared with the slight improvement noted during the previous hour while the temperature was rising from 62°F. to 64°F.

An example of the accuracy to be expected on a day when the data utilized for a determination of t_c are less reliable is afforded by Fig. 3. In this case the elevation of the top of the clouds was estimated by an observer on a nearby mountain top several thousand feet above the cloud deck. The ceiling at Burbank was also merely estimated by the observer. The effect of these estimates upon t_c is two-fold, first because t_c is a function of the thickness of the cloud which is subject to error in this case, and second because it is a function of the lapse rate above the cloud, also subject to considerable error here, since the temperature of the cloud top, as determined under these conditions, is a function of both the cloud thickness and the cloud height. In addition to these difficulties, mist fell during the preceding night, necessitating the use of the diurnal curve for moist soil in determining the breaking time. This curve is subject to more deviation than that for dry soil. Notwithstanding all of these sources of error, the result obtained seems satisfactory for practical purposes. The critical temperature was found to be 64.4°F. The temperature at Burbank at 4:41 a.m. was 57°F., thus $t_c - x$ is equal to 7.4°F. Utilizing

the appropriate diurnal curve to determine the time of breaking, it is noted that t_c intersects it at about 12:15 p.m. Observations at Burbank near the time of breaking on this day are as follows:

BURBANK 5-25-36

Time	Ceiling Ft.	Sky Condition	Temp. °F	Remarks
12:41	1300 estimated	overcast	66	thin spots
13:41	unlimited	scattered clouds	69	5/10 stratus
14:41	unlimited	clear	72	

It is interesting to note that the proper time of breaking would have been obtained from the diurnal curve if the critical temperature could have been obtained more accurately. As it was, the computed breaking time was within about one hour of the actual breaking time. Considering the sources of error in the computation of t_c, the result is quite satisfactory and could be used with more confidence than a guess made at 4:30 a.m.

It is interesting to compare conditions at a coastal station on the same day with those just discussed for Burbank, which is about twenty miles from the ocean. Fig. 4 shows the construction used to compute t_c at San Diego, California, on this day. Unfortunately, the sounding utilized was taken rather late in the day and is not useful in preparing a forecast but will serve to illustrate the point to be brought out, since t_c is independent of the time of day. A rather high value of $t_c - x$ was found for this time of observation, which, coupled with the small amplitude of the diurnal curve, eliminates the possibility of the cloud deck breaking on this day. This is shown in Fig. 4 by the fact that t_c does not intersect the diurnal curve. The observed maximum temperature was 67°F. on this day, well below t_c and the sky remained overcast at all coastal stations during the entire day. If the data necessary for the computation of t_c had been available in the early morning, the result would have been the same, since it is not affected by the time at which the observation is made. Thus one could anticipate that the sky would clear at inland stations on this day but remain overcast at coastal stations. It is interesting to note that the temperature at which the clouds broke over the land was *lower* than the critical temperature at the coast, a fact favoring the convective theory of cloud dissipation, for if radiation was the mechanism providing the heat necessary for the breaking of the clouds, the temperature over the land when the system broke should have been *higher* than the critical temperature at the coastal station, since the cloud top at both stations is practically the same and the cloud layers of the same thickness. The reason for the lower critical temperature at Burbank is to be found in the difference in elevation of the two stations and the fact that the lapse rate under the cloud is adiabatic. Burbank is over 200 meters higher than San Diego, so that other things being equal, the critical temperature at Burbank should be about 2°C. lower than that at the coastal station.

For longer period forecasts, the effect of the synoptic situation upon upper air structures, as well as the secondary influences of radiation and turbulence, must be considered. This subject warrants a rather detailed discussion and will be left to a subsequent paper. In the writer's experience, the method outlined above has proved useful in cases where rather accurate timing of fog and stratus dissipation was desired. It is offered here in the hope that it may find a more general application and that continued usage will lead to further refinements.

Approximate Span-Load Distribution for Preliminary Design

HENRY A. PEARSON, *National Advisory Committee for Aeronautics*

Presented at the General Aerodynamics Session, Fifth Annual Meeting, I.Ae.S.
January 28, 1937

AMERICAN designers have, until recently, depended upon very simple rules for determining the span-load distribution to be used in airplane design. However, the use of highly tapered wings, wings with double taper, and wings with partial-span flaps have indicated the need for applying more rational methods of specifying the load variation. One way of fulfilling this need is to use theoretical methods for determining span-load distribution. Since most designers are unfamiliar with the theoretical methods and the computations required, the N.A.C.A. has prepared charts[1] giving the theoretical distributions for the most commonly used wings, *i.e.*, linearly tapered wings with rounded tips. These distributions have been given for various aspect ratios, taper ratios, and for twist distributions that vary from a uniformly increasing one to one that changes abruptly, as occurs when a flap is deflected. In spite of this simplification, the theoretical distributions are not readily adaptable for estimating the moment and shear at a section, items which the designer is primarily interested in, because a graphical integration of the load curves is required.

In the following derivation an attempt is made to provide a simple approximation that may be used in lieu of the strictly theoretical methods to obtain results which, for structural purposes, are practically equivalent to those obtained from both the theoretical and experimental load distributions. By the use of this simple method, the load, shear, and bending moment at any wing section along the span, due to the air loads, may be found for all non-twisted linearly tapered wings with rounded tips. Formulas are also given which take into account the effect of wing weight distribution along the span. Thus it is possible to estimate quickly the net load at any section for this type of wing.

Derivation of Equation for Air Load Distribution

Fig. 1 shows the variation in shape of the theoretical span-load curves when the taper ratio is varied and when the ordinates at the center are kept the same. Although these curves are for wings with rounded tips and of an aspect ratio of 6, the curves for other aspect ratios are quite similar; the difference being that, as the aspect ratio is increased, the load curves approach closer to the chord distribution curves. As an example,

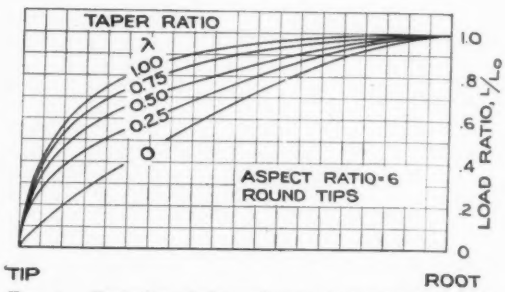

FIG. 1. Variation of theoretical load distribution with taper.

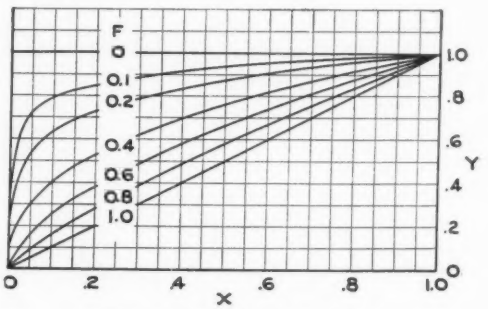

FIG. 2. Variation of y with x^f.

the load curve for a pointed wing of an aspect ratio of 20 would appear even more triangular than the curve for a similar wing of an aspect ratio of 6. These curves are for wings where the rounding at the tip is elliptical and starts at a distance in from the tip equal to the fictitious tip chord obtained by extending the wing leading and trailing edges. Slight differences from this method of rounding are of little consequence in the following method.

Fig. 2 shows a plot of the simple equation

$$y = x^f$$

where the origin is taken at the left. It is at once apparent that there is a marked similarity between the curves of Figs. 1 and 2 and that for practical purposes the load per foot run might easily be given by an empirical expression such as

$$L_a = Kx \qquad (1)$$

where K is a factor that will depend upon the airplane weight, load factor, and wing plan form;
x is a distance measured in from the extreme tip, in feet;

[1] Raymond F. Anderson, *Aerodynamic Characteristics of Tapered Wings*, N.A.C.A. Tech. Rep. No. 572, 1936.

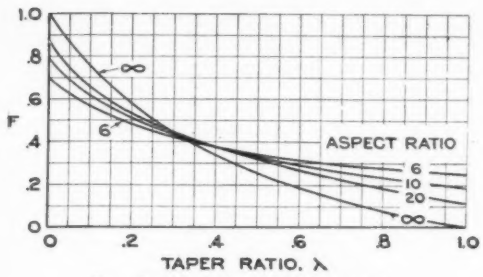

FIG. 3. Variation of f with taper.

and f is a factor dependent upon both taper and aspect ratio.

Eq. (1) is the basis of the approximate method for determining the air load. The factors K and f of Eq. (1) were determined so that the loads, shears, and moments at every point along the span were in as good an agreement as possible with those obtained from strictly theoretical curves. Since K is merely a scale factor, *i.e.*, it multiplies the ordinates of the $y = x^f$ curve so that the loads, or areas, under the theoretical and empirical curves of Figs. 1 and 2 are the same, it may be found from the knowledge that at the wing root, or center, the total vertical shear must be equal to the design load on half the wing. This is given by the integral of the $L_a = Kx^f$ curve between the wing tip and the root. The "shape factor" f was determined by two methods, both of which were found to give very nearly the same result. The first method was simply to compare the different curves of Figs. 1 and 2 by superposition, and then choose the value of f which gave the closest agreement in shape. The second method of determining f was by equating the moments at the root, as obtained from the theoretical distributions, to those obtained by integrating the empirical shear equation and and then solving for f. The variation of f with taper ratio, as determined by the foregoing methods, is given in Fig. 3 for several aspect ratios. Substituting the values for K and f, the approximate equations for the load, shear, and moment at a point, due to the air loads, become

$$L_a = \left[\frac{nW}{2}\,\frac{f+1}{(b/2)^{f+1}}\right]x^f$$

$$S_a = \left[\frac{nW}{2}\,\frac{1}{(b/2)^{f+1}}\right]x^{f+1} \qquad (2)$$

$$M_a = \left[\frac{nW}{2}\,\frac{1}{(f+2)(b/2)^{f+1}}\right]x^{f+2}$$

where the additional terms introduced are defined as: n, the design-load factor; W, the airplane weight in lbs.; $b/2$, the wing semi-span in feet; S_a, the shear at a point in lbs.; and M_a, the moment at a point in lb.-ft.

It can be seen that the computations required by these equations may easily be made on an ordinary log slide rule once the proper constants are known.

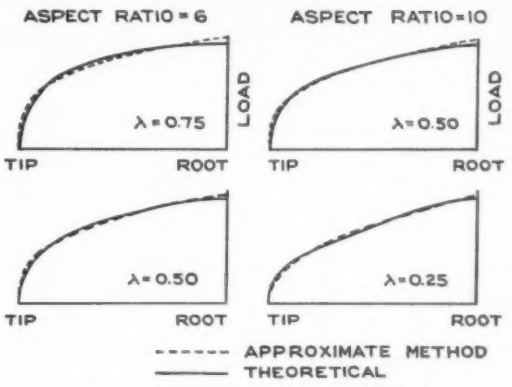

FIG. 4. Comparison of load distributions.

Several comparisons between the approximate curves and the theoretical curves are given in Fig. 4, for aspect ratios of 6 and 10 and for several taper ratios. Previous comparisons between the purely theoretical and experimental load distribution have indicated good agreement for wings of slight taper and of conventional aspect ratio provided that the tip is well rounded. For taper ratios below $\lambda = 0.50$ the agreement is good even with blunt tips.

When applying the method, the factor f should be determined from an aspect ratio computed as though the wing continued uninterrupted through the fuselage. The wing semi-span may then be taken either as the distance from the wing tip to the wing root or to the airplane center line, depending upon whether it is desired to have the wings carry all of the air load or to let the fuselage carry its proportionate share. Recent tests[2] indicate that the conventional fuselage tends to carry as much load as would the wing that it displaces.

Derivation of Equations for Wing Weight Distribution

Up to this point the development has been concerned with the effects arising from the aerodynamic load distribution, no attempt being made to take into account the weight distribution along the span. Results of tests by H. W. Sibert at Wright Field indicate that the wing weight at any section along the span varies according to the equation

$$w = Dc^a \qquad (3)$$

where, w is wing weight per foot of span in lbs., D and a are empirical constants dependent upon wing taper, aspect ratio, and design-load factor, and c is the chord in feet.

Eq. (3) is assumed to hold for that part of the weight distribution due to ribs, spars, covering, wiring, ailerons, control tubing, and other distributed loads, but does

[2] Eastman N. Jacobs and Kenneth E. Ward, *Interference of Wing and Fuselage from Tests of 209 Combinations in the N.A.C.A. Variable-Density Tunnel*, N.A.C.A. Tech. Rep. No. 540, 1935.

not include increases in distribution resulting from such concentrated items as engines and landing gears, which are housed in the wing. It does include, however, the effect that such concentrated items have on the size of members inboard of the load.

If the chord of the linearly tapered wing is expressed in terms of taper ratio, root chord, and distance in from the tip, analytical expressions for the load, shear, and moment at a section, due to the weight distribution, may be derived. These equations for a design load factor n are

$$w = nDc_s^a \left[\left(\frac{1-\lambda}{b/2}\right)x + \lambda\right]^a$$

$$S_w = \frac{nDc_s^a}{a+1}\,\frac{b/2}{1-\lambda}\left\{\left[\left(\frac{1-\lambda}{b/2}\right)x + \lambda\right]^{a+1} - \lambda^{a+1}\right\} \qquad (4)$$

$$M_w = \frac{nDc_s^a}{a+1}\,\frac{b/2}{1-\lambda}\left[\frac{b/2}{(a+2)(1-\lambda)}\left\{\left[\left(\frac{1-\lambda}{b/2}\right)x + \lambda\right]^{a+2} - \lambda^{a+2}\right\} - x\lambda^{a+1}\right]$$

where, λ is the ratio of fictitious tip chord (formed by extending the leading and trailing edges of the wing to the tip) to the root chord, x is the distance in from the tip in feet, $(b/2)$ is the wing panel semi-span in feet, and c_s is the wing root chord in feet. Although Eqs. (4) appear complicated, they really are not, since most of the terms are constants for a given wing and need be computed only once. The values obtained by these formulas are to be subtracted from those given by Eq. (2), at the same values of x, to obtain the net design loads.

An analysis of the previously mentioned Wright Field tests indicates that the factor a varies from 1.85 to 2.1 in the case of four wings representing current design practice, while the factor D was found to vary from 0.294 to 0.380 for the same wings. It can be seen that the factor a varies only slightly for the wings measured and that, until more complete data are available, an average value of 2 may be used. The average value of D appears to be 0.34; but, since D varies between fairly wide limits, which will depend principally upon type of construction, and design load factor, it may be better to determine it from the following, easily verified, equation:

$$D = \frac{(a+1)(1-\lambda)}{(b/2)c_s^a(1-\lambda^{a+1})}\,W_w \qquad (5)$$

The weight of one-half the wing, W_w, which excludes the concentrated load items, is to be estimated from results of previous designs. It can be seen that a substitution of the value of D given by Eq. (5) and a value of 2 for a will simplify the more general Eqs. (4) as several of the factors will cancel.

The effect of heavy concentrated items on the load, shear, and moment may be easily taken into account afterward in the regular manner, by considering the effect of each item in turn.

In the application of Eqs. (4) to determine effects of wing weight distribution it is necessary to use for W_w, $(b/2)$, c_s, and λ, the dimensions and characteristics based on the actual wing panel and not to consider the part intercepted by the fuselage.

Book Review

The Technology of Plastics, by HERBERT W. ROWELL; Plastics Press, Limited, London, 1936; 206 pages, ill.

In his ceaseless search for the magic material that will enable him to combine the requisite high strength and low weight with a material cost far below present aircraft standards and with the full advantages of mass production in cost saving, the aircraft designer periodically casts a longing gaze upon the plastics in their infinite variety. In an art developing so rapidly that to keep literally abreast of it has required a news-reel rather than a library, the major problems have been to learn the physical properties of the available materials and to learn of their adaptability to fabrication by various processes.

Mr. Rowell, who approaches the subject as a chemical engineer rather than as one responsible for the application of the plastic materials in structures, has little to contribute to the first of those quests after knowledge but much to the second. His book makes scarcely even passing comment on the strength, toughness, and freedom from deterioration of the materials that it describes; but it does give a very useful understanding of the subdivision and classification of the plastic field, of the relations of its various members to one another, and especially of the ways in which the various substances can be worked. In treating of classification, the point of view is primarily that of the chemist, with formidable diagrams displaying the internal structure of such molecules as $C_6H_4CH_3OH$.

There remains, however, enough to give the engineer without elaborate chemical background an understanding of the difference between thiourea resinoids and polymerized acrylic plastics and the like, and of the reasons why each of the several types maintains a separate existence in its own field of employment.

Still better, the non-chemical reader will glean a mass of useful information on shop practice for each of the many plastic groups, and especially on the technique, the kinds of equipment, and the manner of skill required in making small molded parts for various purposes.

In short, a highly specialized book, treating in some detail of matters with which probably not 10 percent of the Institute's members have any direct association or any need for elaborate instruction; but likely to be of marked interest and real value to that minor fraction.

EDWARD P. WARNER

A Simplified Analysis of Static Longitudinal Stability

ELLIOTT G. REID, *Stanford University*

(Received February 11, 1937)

ABSTRACT

The first section of this paper describes the development of a single family of curves which illustrates the variation of the pitching moment coefficient with the lift coefficient for all wings and for all c.g. locations. The second consists of an analysis of the characteristics of these curves and their derivatives in conjunction with the known properties of tailplanes; the elements of a simplified theory of static stability are stated in four general theorems. In the third section, a direct method for the determination of tailplane area is given. An example of the use of the simplified analysis is appended.

OF ALL the problems which confront the airplane designer, that of providing an airplane with specified characteristics of static longitudinal stability is one of those least amenable to direct solution. This situation has its root in the difficulty of clearly describing the apparently complex relation between the wing pitching moment coefficient and the several variables which control its value. To be sure, there are analytical and nomographic methods, notably those developed by Stalker[1] and Higgins,[2] which enable fairly accurate calculation of the slope of the wing moment curve when the location of the center of gravity is known. However, visualization of more than the outstanding qualitative characteristics of the underlying relationship is precluded by the fact that for each c.g. position there is an unique relation between the slope of the wing moment curve and the lift coefficient. Such complexity precludes an entirely clear conception of the specific problems of design and makes the use of "cut and try" methods almost universal. The present paper describes a method of correlating the pitching moment characteristics of all practically useful wings, outlines the elements of the simplified theory of static longitudinal stability which naturally follows and illustrates the applicability of these principles to practical design problems.

WING PITCHING MOMENTS

The theorem of statics which states that any force may be replaced by a force and a couple justifies the replacement of the conventional wing vector sheaf, Fig. 1a, by its equivalent, Fig. 1b, in which each force vector is accompanied by the couple $C_{m\,a.c.}$ (Diagrams

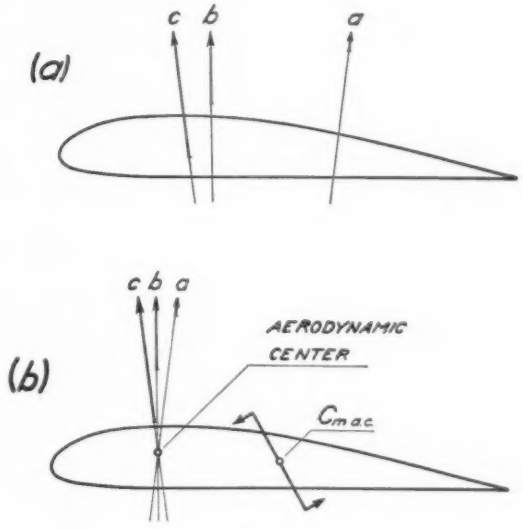

FIG. 1.

of this form will be referred to as "concentrated" vector sheaves and the individual force vectors will be identified with particular values of C_L rather than with values of α.) This form of representation suggests decomposition of the pitching moment about any axis into one constant and one variable component. The first is that due to the couple; regardless of the position of the moment axis (c.g. location) or the value of the lift coefficient, this component has the constant value $C_{m\,a.c.}$ The second is that due to the force vector; its value varies with both the lift coefficient and the c.g. location. This variable component of the wing pitching moment coefficient is designated ΔC_m; attention will be concentrated upon it because static stability is controlled by the shape, rather than the location, of the pitching moment curve.

The variation of ΔC_m with C_L and with c.g. location will be considered, first, in the case of an airfoil of known profile and aspect ratio. For this purpose, a special set of polar coordinates is adopted in which the origin coincides with the aerodynamic center of the airfoil, the direction of the polar axis ("lift axis") is that of the wind at zero lift and the unit of length is the wing chord. In Fig. 2, the moment of the vector C_R about the arbitrarily located c.g. is

$$\Delta C_m = C_R \sin(\gamma - \beta) r \qquad (1)$$

[1] Edward A. Stalker, *Principles of Flight, Chapter 14*, The Ronald Press Company, New York, 1931.

[2] George J. Higgins, *A Study of the Pitching Moments and the Stability Characteristics of Monoplanes*, N.A.C.A. Technical Note No. 511, 1934.

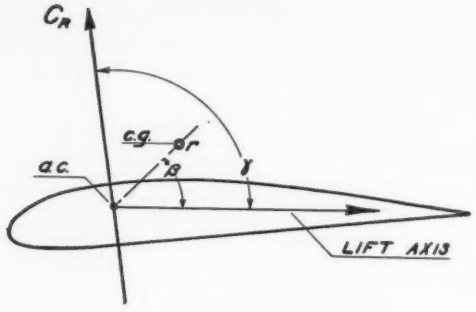

FIG. 2.

whence $$\frac{\Delta C_m}{r} = C_R \sin(\gamma - \beta) \qquad (2)$$

Since both C_R and γ depend only upon C_L, it appears that a single curve of $\Delta C_m/r$ *vs.* C_L implicitly defines the relation between ΔC_m and C_L for all c.g. positions on the radius vector which has the polar angle β. Similarly, a single family of curves (*e.g.*, Fig. 3) completely defines the relation between ΔC_m, C_L, and c.g. location. Given such a chart and the coordinates of the c.g. (r_1, β_1), the value of ΔC_m which corresponds to a specific lift coefficient, C_{L_1}, is obtained by reading (or interpolating) the value of $(\Delta C_m/r)_{\beta_1 C_{L_1}}$ from the chart and multiplying it by r_1.

Although the preceding development gives no indication of the fact, the curves of Fig. 3 are applicable to wings of all profiles and plan forms likely to be used in present-day airplane design. This really means that, insofar as ΔC_m is concerned, a single "concentrated" vector sheaf will serve to represent the characteristics of all practically useful airfoils. This is explained as follows:

The foundation of modern airfoil theory is the concept that with elliptic span loading the value of the lift coefficient and the location and orientation of the resultant force vector with respect to the lift axis depend, in the case of a given profile, only upon the value of the effective angle of attack. Although the magnitude of C_R varies with sec α_i when C_L = const., this variation does not exceed 0.005 C_R so long as $C_L < 1.5$ and $AR > 5$. Therefore, the vectors of the concentrated sheaf are unaffected by variations of aspect ratio so long as the loading is elliptic. The introduction of non-elliptic loading causes the induced angle of attack and the induced drag to increase by amounts proportional to the values of the induction factors τ and δ, respectively. The resulting effect upon the vector which corresponds to a particular lift coefficient is to alter its orientation with respect to the lift axis by the angle $\alpha_i(\tau - \delta)$, wherein α_i corresponds to elliptic distribution. Although the loading of the wings of most modern airplanes approaches the elliptic form so closely that this refinement is of no importance, it seems worth pointing out that even with rectangular wings $\alpha_i(\tau - \delta)$ does not exceed 0.6 degree when $AR > 5$ and $C_L < 1.5$. These considerations justify the conclusion that the concentrated vector sheaf and the curves of ΔC_m *vs.* C_L are not appreciably influenced by practical variations of wing plan form.

Since the effect of aspect ratio is inconsequential, the examination of profile characteristics may be simplified by assuming the aspect ratio to be infinite. It is obvious that if the air were inviscid and if all infinite aspect ratio airfoils conformed with Kutta's hypothesis that $C_L = 2\pi \sin \alpha_0'$, the "concentrated" vector sheaves for all profiles would be identical. Therefore, such discrepancies as do exist among the concentrated vector sheaves of real airfoils can only arise from differences of C_{D_0} and of $dC_L/d\alpha_0$. Since the magnitude of the vector which corresponds to a given lift coefficient is negligibly affected (unless C_L is extremely small) by the variations of C_{D_0} which actually occur and is not at all influenced by those of $dC_L/d\alpha_0$, variations of the angle γ at constant values of C_L will constitute the only

TABLE 1[3]

No.	Airfoil	$C_{L\ max.}$	$C_{D0\ min.}$	C_{m0}	$dC_L/d\alpha_0$	$\frac{C_{L\ max.}}{C_{D0\ min.}}$
1*	N.A.C.A. 0006	0.88	0.0065	0	0.102	86
2	N.A.C.A. 0018	1.59	.0108	0	.099	147
3*	N.A.C.A. 2306	1.04	.0073	−0.036	.104	142
4	N.A.C.A. 2518	1.48	.0112	− .047	.096	154
5	N.A.C.A. 4412	1.65	.0092	− .089	.100	179
6*	N.A.C.A. 6518	1.61	.0141	− .139	.095	114
7*	N.A.C.A. 6712	1.95	.0126	− .206	.095	155
8	N.A.C.A. 23012	1.60	.0086	− .007	.103	186
9	Clark Y	1.57	.0100	− .069	.099	157
10	N.A.C.A. 2218–09	1.61	.0100	− .029	.089(?)	161

[3] Compiled from Variable Density Wind Tunnel test results, none of which are corrected to the "effective Reynolds Number." Sources of data: 1–7, N.A.C.A. T.R. 460; 8, T.R. 530; 9, T.R. 416; 10, T.N. 487.

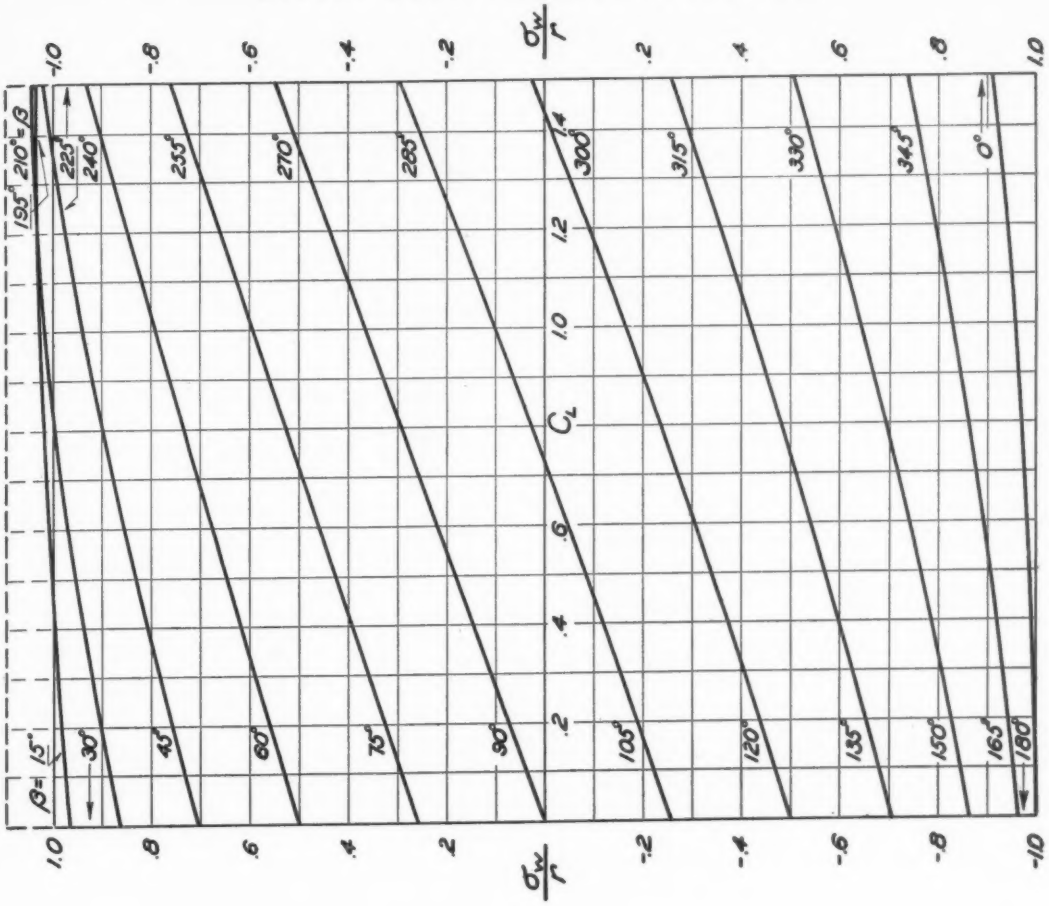
$\frac{\sigma_w}{P}$
C_L
β= 15°
195° 210°=β
225°
240°
255°
270°
285°
300°
315°
330°
345°
0°
30°
45°
60°
75°
90°
105°
120°
135°
150°
165°
180°

FIG. 7.

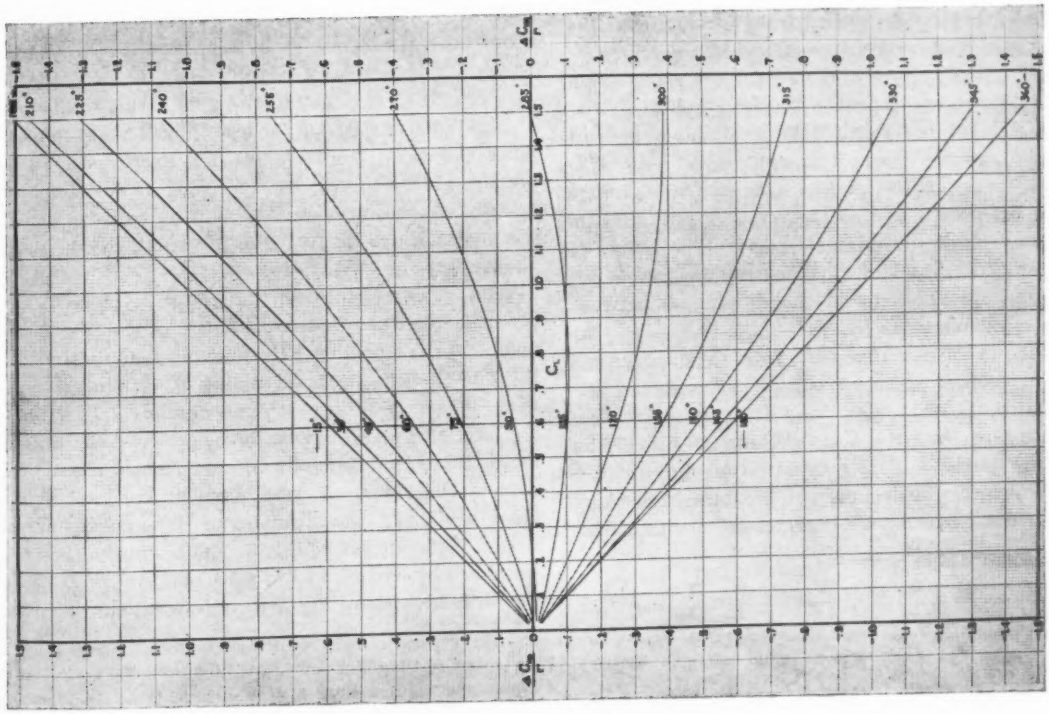
$\frac{\Delta C_m}{P}$
C_L
$\frac{\Delta C_D}{P}$

FIG. 8.

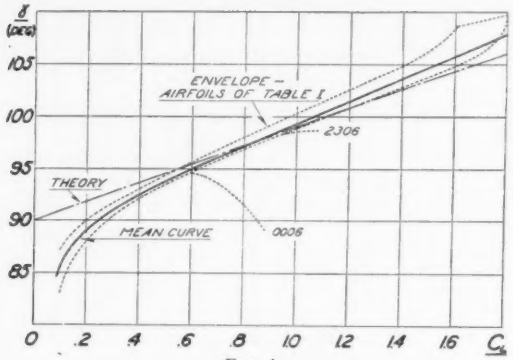

FIG. 4.

ponderable evidence of discrepancy between elementary theory and reality.

In Fig. 4, the curve designated "theory" defines the variation of γ with C_L which would occur if $AR = \infty$, $C_{D_0} = 0$ and $C_L = 2\pi \sin \alpha_0'$. The actual variations of γ with C_L for the diversified group of airfoils whose principal characteristics appear in Table 1 are shown by the same chart.

The values of γ have been calculated by substituting the characteristics of these airfoils in the equation

$$\gamma = \alpha_0' + \tan^{-1} \frac{C_L}{C_{D_0}} \qquad (3)$$

in which α_0' is measured with reference to the angle of zero lift and C_L and C_{D_0} are the corresponding coefficients.

Some of the profiles included in the preceding table (those identified by asterisks) may be eliminated from further consideration because they are obviously unsuitable for the wings of modern airplanes. Sections 1 and 3 are so thin as to be structurally impractical; the former is not even aerodynamically desirable since its value of $C_{L\ max.}/C_{D_0}$ is only 86. Airfoil 6 is excluded on the ground of excessive profile drag and small value of $C_{L\ max.}/C_{D_0}$. The prohibitively large pitching moment coefficient of profile 7 bars it from practical use. The empirical "mean curve" of Fig. 4 defines the average variation of γ with C_L for the remaining practically useful members of the original group. The effects of finite profile drag and of smaller-than-theoretical lift curve slope are apparent in the differences between the theoretical and mean curves.

Fig. 5 shows the deviations of γ from the mean curve[4] for the six profiles which are considered as representative of current design practice. It is apparent that within the range between $C_L = 0.1$ and $0.9\ C_{L\ max.}$ this deviation exceeds $\pm 1°$ in only one case and there is reason to suspect the accuracy of the data from which this curve was derived.[5] It is therefore concluded that

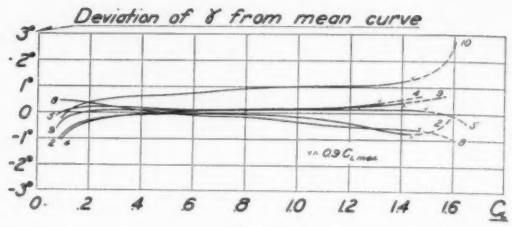

FIG. 5.

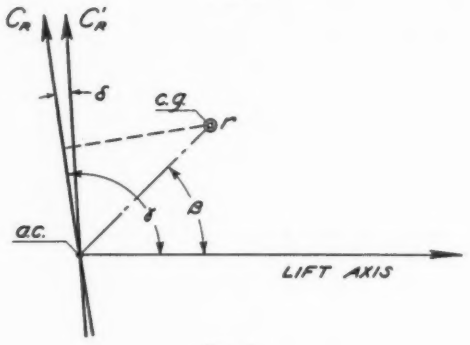

FIG. 6.

the use of a universal vector sheaf based upon this mean curve is not likely to involve errors of vector direction greater than $\pm 1°$.

The applicability of a single set of $\Delta C_m/r$ *vs.* C_L curves to all practically useful profiles can now be investigated quantitatively. Suppose that the vector C_R, in Fig. 6, represents the actual resultant force experienced by a certain airfoil at a given lift coefficient and that C_R' is the one defined by the mean curve of Fig. 4. Having equal magnitudes but slightly different directions, these two vectors produce moments (ΔC_m) about the c.g. which differ by the amount $rC_R \cos(\gamma - \beta) \sin \delta$. The greatest possible error in $\Delta C_m/r$ (when $\cos(\gamma - \beta) = 1$) is seen to be $C_R \sin \delta$ which, when $\delta = 1°$, amounts to 0.017 C_R or less than 2 percent of C_L. Since the mean curve values of γ were used for the preparation of Fig. 3, the foregoing calculation justifies the conclusion that this chart is applicable to all wings which are likely to be incorporated in modern airplanes.

When it is remembered that the wing moment coefficient is made up of one constant ($C_{m\ a.c.}$) and one variable (ΔC_m) component, the universal applicability of the curves just discussed makes it evident that the *shape of the wing moment curve depends only upon the c.g. location.*[6] An obvious development based on this fact is the preparation of a complementary chart which depicts the slopes of wing moment curves. Such a chart is Fig. 7; the ordinates of these curves are the slopes of the curves of Fig. 3. The notation has been simplified by writing σ_w/r in place of $d(\Delta C_m/r)/dC_L$ and the ordinate scale of Fig. 7 is so designated. To deter-

[4] Coordinates of mean curve:

C_L	0.1	.2	.3	.5	.8	1.2	1.6
γ (deg.)	85.6	89.1	91.0	93.8	97.1	101.5	105.8

[5] The value of $dC_L/d\alpha_0$ is unusually small in the case of profile 10; an increase of lift curve slope would reduce the apparent discrepancy.

[6] The vertical translation of the C_{mw} *vs.* C_L curve which results when one profile is substituted for another—while r and β remain unaltered—is illustrated by Fig. 9.

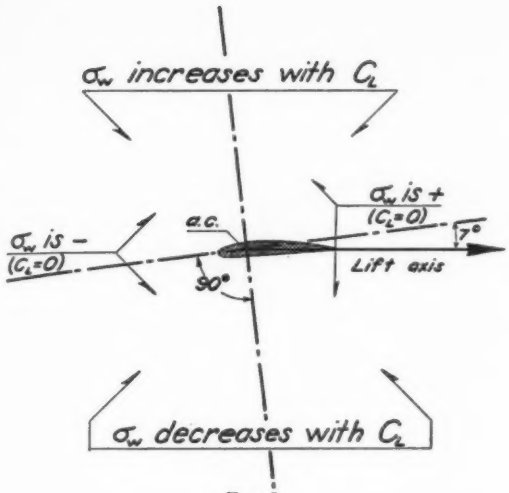

FIG. 8.

mine the value of σ_w (the slope of the curve C_{mw} *vs.* C_L) which corresponds to the specific values r_1, β_1, and C_{L_1}, it is only necessary to read from Fig. 6 the value of $(\sigma_w/r)_{\beta_1 C_{L_1}}$ and to multiply it by r_1, *i.e.*,

$$\sigma_w = \left(\frac{\sigma_w}{r}\right)_{\beta_1 C_{L_1}} \times r_1 \tag{4}$$

The slope characteristics of the wing moment curves for all c.g. locations are revealed by Fig. 7. In lieu of a series of literal statements, these characteristics are graphically summarized in Fig. 8. This illustration provides a definite "reference frame" which has long been needed for the accurate segregation of those known features of wing moment curve shape which have, in the past, been somewhat indefinitely identified with high, low, forward, and aft locations of the center of gravity. Additional information of a quantitative character can be obtained by a study of Fig. 7.

Analysis of Static Longitudinal Stability

In studies of the static stability of complete airplanes, it is customary to neglect the pitching moments contributed by all parts other than the wing and tailplane. With this simplification,

$$C_{mr} = C_{mw} + C_{mt} \tag{5}$$

The subscripts r, w, and t identify the resultant, wing and tailplane moment coefficients, respectively.

The slope of the resultant pitching moment curve is

$$\frac{dC_{mr}}{dC_L} = \frac{dC_{mw}}{dC_L} + \frac{dC_{mt}}{dC_L} \tag{6}$$

or, writing $\sigma = dC_m/dC_L$,

$$\sigma_r = \sigma_w + \sigma_t \tag{7}$$

This relation assumes great significance when it is remembered that, in the absence of interference and within the range in which the wing lift curve (C_L *vs.* α) is rectilinear, the "curve" C_{mt} *vs.* C_L is a straight line,

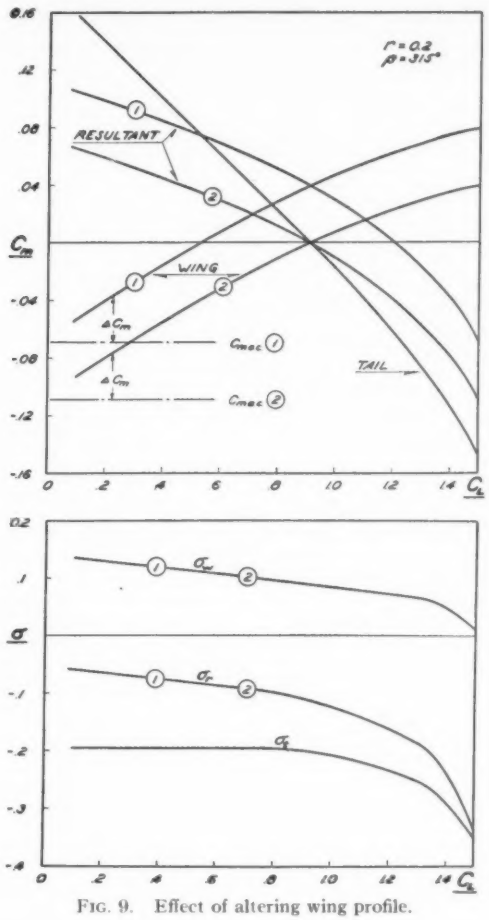

FIG. 9. Effect of altering wing profile.

i.e., σ_t is constant. Although one might not guess it from an inspection of wing lift curves, this constant slope characteristic of the tail moment curve actually prevails throughout the normal level flight speed range of the modern airplane, *i.e.*, the upper 80 percent of the range of speeds available without the use of flaps.[7] Within this range and under the conditions previously stated, it is evident that

$$\sigma_r = \sigma_w + A \tag{8}$$

which means that the slope of the resultant pitching moment curve differs by a constant amount from that of the wing.

When interpreted in the light of the preceding analysis of wing moment characteristics, this equation yields the following general theorems of static stability.

(1) *When the center of gravity has a fixed location* (r, β), *the static stability of an airplane is not influenced by alterations of wing profile or changes of tail setting; they affect only the angle of trim.*

[7] For example, assume $V_{max.} = 2.75\ V_{min.}$ Most lift curves are rectilinear up to at least $0.6\ C_{Lmax.}$ At $0.6\ C_{Lmax.}$, $V = 1.29\ V_{min.}$ Result: $(2.75–1.29)V_{min.}/(2.75–1)V_{min.} = 0.835$ or 83.5 percent of speed range.

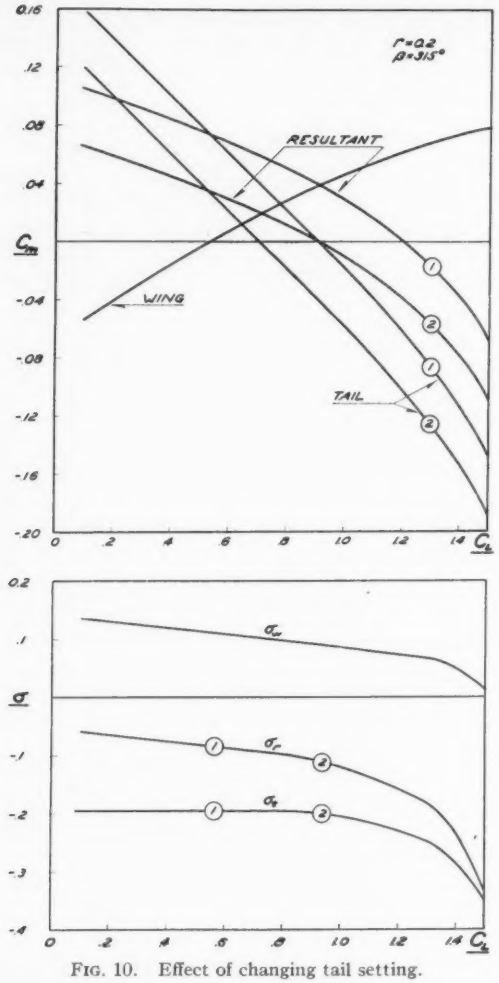

FIG. 10. Effect of changing tail setting.

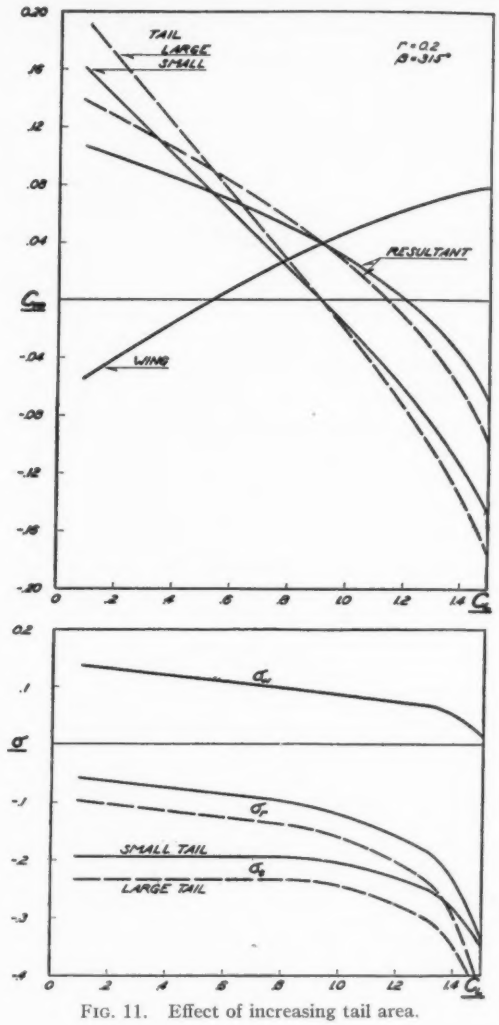

FIG. 11. Effect of increasing tail area.

The independence of σ_w and wing profile has been discussed previously and is illustrated by Fig. 9. The value of σ_t, or A, is unaffected by an alteration of tail setting because this results only in a vertical displacement of the curve of C_m *vs.* C_L, as shown in Fig. 10. (The only exception occurs when α_t exceeds the limits of the range within which $C_{Lt} = \alpha_t \times$ constant, an unusual condition in practical design.)

(2) *When the center of gravity has a fixed location* (r, β), *the static stability of an airplane is controlled primarily by the form and location of the tailplane; it is affected slightly by the influence of wing plan form upon lift curve slope and downwash.*

Since the value of σ_w, for any particular value of C_L, is fixed by the c.g. location, the corresponding value of σ_r can be altered only by varying A. The dependence of A upon the area, aspect ratio and location of the tailplane is quite apparent. Wing plan form (or character of cross-span lift distribution) must be added to this list for two reasons. First, it affects the angle of downwash. Second, the conventional index of static stability is $dC_{mr}/d\alpha$, or σ_r', and since $\sigma_r' = \sigma_r dC_L/d\alpha$ wing plan form affects the value of σ_r' through its influence upon $dC_L/d\alpha$. The effect of increasing the value of A (by enlarging the tailplane) is illustrated by Fig. 11.

(3) *When the center of gravity has a fixed location* (r, β), *the effect of altering the area, aspect ratio or location of the tailplane is to produce a uniform change of the index of static longitudinal stability throughout the useful speed range of the airplane.*

Since the curve σ_w *vs.* C_L is fully determined by the c.g. location, the only effect of altering the design of the tailplane is to change the value of the constant A. The net result is, therefore, either a uniform increase or decrease of the original values of σ_r within the normal flight range. This is illustrated by Fig. 11. The change of the index of static stability (σ_r') is likewise uniform throughout this range because, with any given wing aspect ratio, the value of σ_r' varies directly with that of σ_r. Close examination of Fig. 11 will reveal that the changes in σ_t and σ_r are not uniform beyond the range within which σ_t is constant. At these larger lift

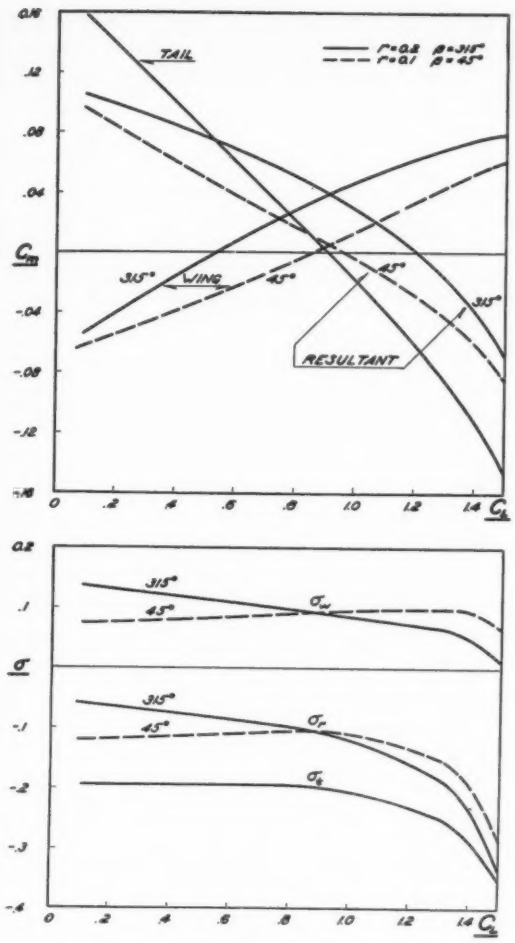

FIG. 12. Effect of altering c.g. location.

coefficients, the changes are proportional to the original values of σ_t.

The reader may wonder at the omission of wing aspect ratio from the list of design variables covered by this theorem. The reason is that while alterations of wing aspect ratio do produce uniform changes in σ_r throughout the normal flying range, the corresponding changes of σ_r' are not uniform. This is the result of the variation of $dC_L/d\alpha$ with aspect ratio.

(4) *When the plan form of the wing is fixed, the location of the center of gravity* (r, β) *is the only design factor which influences the* **variation** *of the static stability of an airplane within its useful speed range,* i.e., *the* **change** *of* σ_r *or* σ_r' *between given values of* C_L *or* α.

This is a corrolary to (3) and its validity is established by the proof of that theorem. Its practical significance can hardly be over-emphasized because it enables the designer to determine, by inspection of Fig. 7, the character and magnitude of the variation of static stability which will occur within the useful speed range when the center of gravity of an airplane has any particular location. Curves which characterize two c.g. locations are reproduced in Fig. 12; the essential differences between the results of altering the design of the tailplane and of relocating the c.g. will be appreciated when Figs. 11 and 12 are compared.

Determination of Tailplane Area

Since the pitching moment produced by any conventional tailplane is readily calculable if the downwash and "tail efficiency" are known, the inverse problem of tail area determination offers no greater difficulty, under similar conditions, when the required tail moment or required slope of the tail moment curve can be specified. In fact, it can be shown that the tailplane area required to give σ_r the specific value, $\sigma_{t\ req.}$, at all points within the linear range of the wing lift curve is defined by the following equation:

$$S_t = S_w \frac{\sigma_{t\ req.}}{\eta l\left(\frac{k_t}{k_w} + k_\epsilon k_t\right)} \tag{9}$$

in which

S_w, S_t = Areas of wing and tailplane
η = Tail efficiency
l = Distance, c.g. to tail c.p.—in wing chord lengths
k_w, k_t = Slopes of wing and tailplane lift curves $(dC_L/d\alpha)$
$k_\epsilon = d\epsilon/dC_L$ (Always negative; ϵ = angle of downwash)
(Angles α and ϵ are expressed in degrees.)

It is indicated by this equation that the principal problem involved in satisfying definite requirements of static stability within the normal flight range is that of evaluating $\sigma_{t\ req.}$ In general one can only say that $\sigma_{t\ req.}$ must be equal to $\sigma_r - \sigma_w$ under the conditions of the stability specification. The method of evaluation to be used in an individual case depends upon the character of the wing moment curve and the sort of specification involved. However, the fact that the slope of any wing moment curve may be readily determined by reference to Fig. 7 makes this task a relatively easy one under all conditions.

Since the problem of providing a specified minimum degree of static stability is much more common than that of preventing an excess, only the former will be considered here; analogous methods for dealing with the latter will then be obvious.

When the value of σ_r is specified at some particular speed or lift coefficient, the evaluation of $\sigma_{t\ req.}$ amounts to nothing more than a problem in subtraction, once the σ_w *vs.* C_L curve has been obtained by use of Fig. 7. This is also the case when a maximum value of σ_r (*i.e.*, minimum degree of stability) is specified for a high wing monoplane. With this type the separation between the σ_w curve and the limiting value of σ_r is greatest when the lift coefficient is that corresponding to the

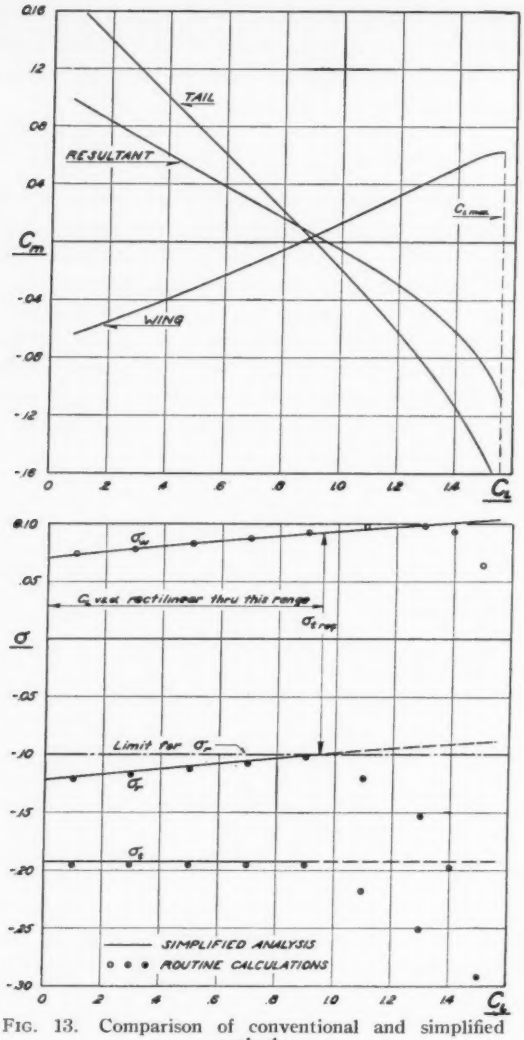

FIG. 13. Comparison of conventional and simplified methods.

highest speed under consideration, *i.e.*, the value of σ_w decreases as C_L increases. (For example, see the curves for $\beta = 315°$ in Fig. 12.) Thus $\sigma_{t\ req.}$ is equal to the difference between σ_r and σ_w at the smallest value of C_L for level flight.

The problem is slightly more complicated when a maximum value for σ_r is specified in the case of a low wing monoplane. With this type, σ_w increases with C_L and it becomes necessary to determine the conditions under which σ_r will attain its maximum value. Figs. 9–13 show that the curve of σ_t *vs.* C_L breaks sharply downward at large lift coefficients, *i.e.*, beyond the linear range of the wing lift curve. (This is, of course, the result of the reduction of $d\epsilon/d\alpha_w$ which occurs at large angles of attack.) It has been found that this characteristic overshadows all others and that the highest point of the σ_r curve invariably occurs at a lift coefficient almost identical with the upper limit of the linear portion of the wing lift curve. Fig. 13 is a typical example of this kind.

Because the methods of dealing with wing and tailplane moments presented in this paper are particularly useful in preliminary studies of static stability, the following simplified equation

$$S_t = 1.06\, S_w\, \sigma_{t\ req.} \tag{10}$$

is suggested for approximate calculations in connection with conventional designs. This equation has been derived from Eq. (9) by substituting $\eta = 0.75$ and the average values of the constants which correspond to $AR_w = 7$, $AR_t = 3$, and to $t = 2.75$.

EXAMPLE

A comparison of the results of routine calculations with those obtained by use of the simplified analysis is presented in Fig. 13. This example concerns a monoplane which has a low wing of rectangular plan form. The low wing position was chosen so that the method of evaluating $\sigma_{t\ req.}$ for this type might be demonstrated; the selection of a rectangular plan form serves to illustrate the small consequences of such departure from elliptic loading.

The calculations are based upon the following data:

c.g. coordinates, $r = 0.1$, $\beta = 45°$.
Wing profile, Clark *Y*; $AR = 7$; *a.c.* at 23.90, 4.05 chd.
Tailplane profile, N.A.C.A. 0012; $AR = 3$.
Tailplane location, on prolongation of wing chord line; $t = 2.75$.
Tailplane setting, $-2°$ with respect to wing chord.
$\eta = 0.75$ $\quad \epsilon = -5.75\, C_L$ (deg.)

It is assumed to be specified that σ_r must not exceed -0.1 between zero and maximum lift. Further, it is considered desirable to avoid excessive static stability insofar as is possible.

The aerodynamic characteristics of the wing and tailplane used in the routine calculations were obtained by the application of accepted methods of correction to data presented in N.A.C.A. Tech. Reports Nos. 416 and 460, respectively. The tailplane area required for satisfaction of the stability specification would ordinarily have to be determined by "cut and try" methods; in this case, the value was actually obtained by use of Eq. (9) in conjunction with the simplified analysis. (Needless to say, the first "trial" proved satisfactory.) Conventional vector sheaves representing the forces on wing and tailplane were then drawn, the moment arms with reference to the c.g. measured and the moment coefficients calculated. These values were used to plot the curves which appear in the upper chart of Fig. 13.

The results obtained by use of the simplified method are represented by the curves which appear in the lower chart of Fig. 13. The curve of σ_w *vs.* C_L was obtained by multiplying the ordinates of the $\beta = 45°$ curve of Fig. 7 by r, *i.e.*, by 0.1. Since the wing lift curve is

linear up to $C_L = 0.95$, $\sigma_{t\ req.}$ was evaluated at this lift coefficient; the result is $\sigma_{t\ req.} = -0.193$. (Substitution of this value in Eq. (9) yields the relation $S_t = 0.195\ S_w$—which was used in the routine calculations.) The "curve" of σ_t *vs.* C_L is accordingly drawn at the ordinate -0.193; drawing the curve of σ_r *vs.* C_L amounts to moving the σ_w *vs.* C_L curve downward by the amount -0.193.

The slopes of the C_m *vs.* C_L curves of the upper chart were determined by graphical methods and these values appear as spots on the lower chart. It will be seen that the simplified method predicts the slope of the wing moment curve with high accuracy over almost its entire length. It is equally evident that the slopes of the tailplane and resultant moment curves are satisfactorily predicted only within the linear range of the wing lift curve. (However, it must be remembered that this corresponds to some 80 percent of normal level flight speed range.) The deviation of the results of the simplified calculations from those of the routine ones at large lift coefficients is necessarily in the direction of greater stability and, unless increased stability is objectionable at low speeds, it is of no practical consequence. The excellent agreement between the two sets of values within the normal flying range and the correct prediction of the maximum value of σ_r demonstrate that the simplified analysis may be used with confidence for the solution of most of the practical problems of static stability.

Conclusion

Recognition of the fact that not only the wing pitching moment but the slopes of both the wing and resultant pitching moment curves, as well, may be separated into one fixed and one variable constituent makes it possible to simplify and consolidate the theory of static longitudinal stability. The principal results of an analysis of these components are four general theorems of static stability, a universal chart which defines the slope of any wing moment curve as a function of the lift coefficient and the c.g. coordinates and a direct method for the determination of tailplane area.

Although the study is presented in terms of the monoplane, its results can be adapted to other wing systems by making use of the concept of an "equivalent monoplane."

It is hoped that an extension of this analysis will result in the development of direct methods for simultaneously satisfying the requirements of static longitudinal stability and controllability.

A Contribution to the Theory of Turbulence

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(Received June 21, 1937)

STUDIES of the problem of Wind-Tunnel Turbulence have recently been published by Taylor,[1] von Kármán,[2] and Dryden.[3] These studies are concerned with the decay of homogeneous isotropic turbulence. The scale and intensity of the turbulence is assumed to be known at a given instant throughout the fluid and the decay with respect to time is asked for.

In this note the authors investigate the turbulence produced at a constant rate in the boundary, and decaying in a direction normal to the surface of generation. This problem, so far as the authors are aware, has not been treated before. The problem becomes especially simple if one considers a fluid in a semi-infinite space bounded by a plane along which the turbulence is produced. The mean motion is assumed to be constant throughout and parallel to the plane.

This investigation is not only of theoretical interest but should be useful in the study of the behavior of turbulent boundary layers, and might be of help in the study of the influence of surface roughness. The stated problem can be treated by means of the equation of the statistical theory of turbulence recently proposed by von Kármán. It furthermore might serve as the basis for an experiment in which the consequences of the theory can be tested.

The considered turbulent motion has statistically an isotropic character due to the absence of mean shear stresses, *i.e.*, the correlations of the velocity components at a certain point in the space with respect to a set of orthogonal axes are independent of the rotation of this system. The turbulence, however, is not homogeneous, since the correlations are functions of the distance from the boundary.

Consider a space with the orthogonal axes x_1, x_2, x_3, in which the fluid is bounded by a (x_1x_3) plane and has a constant mean velocity U in the x_1 direction. The components of the turbulent velocity $\vec{u}$ and vorticity $\vec{\omega}$ may be denoted by u_1, u_2, u_3, and ω_1, ω_2, ω_3, respectively. The following equations for the dissipation of energy and the dissipation of vorticity have been derived by von Kármán:

$$\frac{d}{dx_2}\left[\overline{u_2\left(\frac{u^2}{2}+\frac{p}{\rho}\right)}\right] = \frac{\nu}{2}\frac{d^2\overline{u^2}}{dx_2^2} - \nu\sum\sum\overline{\left(\frac{\partial u_i}{\partial x_k}\right)^2} \tag{1}$$

$$\frac{d}{dx_2}\left[\overline{u_2\frac{\omega^2}{2}}\right] = \frac{\nu}{2}\frac{d^2\overline{\omega^2}}{dx_2^2} - \nu\sum\sum\overline{\left(\frac{\partial \omega_i}{\partial x_k}\right)^2} \tag{2}$$

Neglecting with von Kármán the first terms on the right-hand side of Eqs. (1) and (2) as small compared with the other terms and substituting

$$\sum\sum\overline{\left(\frac{\partial u_i}{\partial u_k}\right)^2} = \frac{k_2\overline{u^2}}{\lambda^2},\quad \sum\sum\overline{\left(\frac{\partial \omega_i}{\partial x_k}\right)^2} = \frac{k_3\overline{u^2}}{\lambda^4},$$

$$\overline{u_2\left(\frac{u^2}{2}+\frac{p}{\rho}\right)} = -\sqrt{\overline{u^2}}\,l_1\frac{d\overline{u^2}}{dx_2},\quad \overline{u_2\frac{\omega^2}{2}} = -\sqrt{\overline{u^2}}\,l_2\frac{d\overline{\omega^2}}{dx_2}$$

where λ is a length characteristic for the scale of the turbulence, Eqs. (1) and (2) take, with

$$l_{1resp.2} = k_{4resp.5}\frac{\sqrt{\overline{u^2}}\,\lambda^2}{\nu} \tag{3}$$

the form

$$\frac{d}{dx_2}\left[\overline{u^2}\lambda^2\frac{d\overline{u^2}}{dx_2}\right] = c_1\frac{\overline{u^2}}{\lambda^2} \tag{4}$$

$$\frac{d}{dx_2}\left[\overline{u^2}\lambda^2\frac{d}{dx_2}\left(\frac{\overline{u^2}}{\lambda^2}\right)\right] = c_2\frac{\overline{u^2}}{\lambda^4} \tag{5}$$

where $c_1 = \dfrac{2\nu^2k_2}{k_4}$, $\quad c_2 = \dfrac{2\nu^2k_3}{k_5}$

The solution of Eqs. (4) and (5) is determined if the following boundary conditions are prescribed:

$$at\, x_2 = 1;\quad \overline{u^2} = u_0^2,\quad \lambda = \lambda_0,$$
$$at\, x_2 = \infty;\quad \overline{u^2} = 0,\quad \lambda = \infty.$$

It seems to be difficult to obtain the general solution of the non-linear system Eqs. (4) and (5). It is, however, possible to give a certain manifold of solutions which are likely of importance. Furthermore, the general relation between $\overline{u^2}$ and λ which must exist under the stated assumptions can be deduced from Eqs. (3) and (4).

To obtain a solution, assume

[1] G. I. Taylor, Proceedings of the Royal Society, London, Vol. 15, I, 1935.

[2] Th. von Kármán, *The Fundamentals of the Statistical Theory of Turbulence*, Journal of the Aeronautical Sciences, Vol. 4, No. 4, pages 131–138, February, 1937.

[3] Hugh L. Dryden, *The Theory of Isotropic Turbulence*, Journal of the Aeronautical Sciences, Vol. 4, No. 7, pages 273–280, May, 1937.

$$\overline{u^2} = Ax^n \quad \text{and} \quad \lambda^2 = Bx^m$$

where A, B, n, and m are constants. This introduced into Eqs. (4) and (5) gives

$$AB^2n(2n + m - 1)x^{(2n+m-2)} = c_1x^{(n-m)} \tag{6}$$

$$AB^2(n - m)(2n - 1)\, x^{(2n-2)} = c_2x^{(n-2m)} \tag{7}$$

Hence

$$n = 2(1 - m) \tag{8}$$

In order to satisfy the assumption $\dfrac{d^2\overline{u^2}}{dx^2} \ll \dfrac{\overline{u^2}}{\lambda^2}$, it is necessary that $m > 2$ and hence $n < -2$.

If the assumed power law is correct the constants m and n can easily be determined experimentally. With known values for n and m the constants c_1 and c_2 can be evaluated by means of Eqs. (5) and (6). If furthermore, the values of k_2 and k_3 are assumed to be known (for instance, equal to the values for isotropic homogeneous turbulence) the ratio of the two mixing lengths l_1 and l_2 can be calculated.

Of interest is the relation between the "mixing length" and the distance from the wall, which can be obtained from Eq. (3).

$$l = \text{const.}\ \frac{\lambda^2\sqrt{\overline{u^2}}}{\nu} = \frac{c}{\nu}x^{(m+n/2)} = \frac{c}{\nu}x \tag{9}$$

It thus can be seen that in this case the "mixing length" is proportional to the distance from the wall.

The general relation between $\overline{u^2}$ and λ is

$$\overline{u^2} = \frac{c_1 - c_2}{3}\left(\frac{\lambda}{\lambda'}\right)^{1/3}\int_1^{x_2}\frac{dx_2}{(\lambda^5\lambda')^{2/3}} + u_0^2\left(\frac{\lambda}{\lambda'}\frac{\lambda_0'}{\lambda_0}\right)^{1/3} \tag{10}$$

which is obtained by subtracting Eq. (5) from Eq. (4) resulting in a differential equation of the first order for $\overline{u^2}$ with coefficients depending on λ and $\lambda' = d\lambda/dx_2$.

In the case of a flow along a flat plate with no pressure gradient, the above prescribed boundary conditions are approximately satisfied at the outer edge of the turbulent boundary layer, due to the slow change of the layer thickness and of the scale and the intensity of the turbulence in the boundary layer in this direction. A rough experimental check on $u^2 = f(x_2)$ indicates that in this case the assumed power law is at least a good approximation. These tests have been carried out in a recently completed wind tunnel for the study of the behavior of boundary layers. Further studies with an improved hot wire apparatus are in progress.

Notes on Tabs

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Presented at the Airplane Stability and Performance Session, Fifth Annual Meeting, I. Ae. S. January 29, 1937

Introduction

BECAUSE of the increasing size and speed of modern aircraft, means must be provided for reducing the control forces if the control surfaces are to be operated manually by the pilot. Among the methods in use for the reduction of control forces are: differential operation of the surfaces; insetting the hinge from the leading edge of the control surface; horn balances; paddle balances; and tabs. This paper deals only with tabs since they appear to be of most general interest at the present time.

Considerable confusion seems to exist regarding the terminology to be used in connection with tabs. They have been called "Flettners," "servos," and "trimmers," and it appears desirable to attempt to classify each arrangement by an adequate descriptive definition.

Definitions of Tabs

Fig. 1 shows various arrangements of tabs in use at the present time and their designations.

The *fixed trimming tab* is used principally for correcting dis-symmetries in the aircraft as, for example, improper rigging of the wings. This tab can be set only while the aircraft is on the ground and its setting remains fixed relative to the movable control surface.

The *controllable trimming tab* may also be used to correct dis-symmetries in the rigging of the aircraft, but its main uses are to take the place of the adjustable stabilizer for longitudinal trim and of the adjustable fin for lateral trim. It is also occasionally applied to the ailerons. This tab is adjustable from the cockpit by the pilot in flight and, for a given setting, it remains fixed with respect to the movable control surface.

The *balancing tab* is used to reduce the force required by the pilot to operate the control surfaces. This tab is linked to the fixed surface so that, as the movable surface is deflected, the tab setting relative to this surface varies and is in the opposite direction. Various ratios of tab deflection to control-surface deflection may be obtained for different degrees of balancing by changing the linkage.

The *balancing and controllable trimming tab* combines the usefulness both of the balancing tab and of the controllable trimming tab in that it permits adjustable trim of the aircraft in flight and reduces the control forces required.

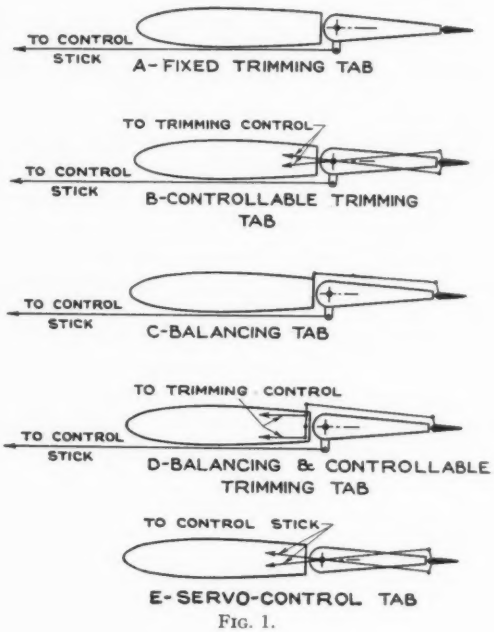

Fig. 1.

The *servo-control tab* is itself directly deflected by the pilot, the effects produced by the tab causing the main movable surface to which it is attached to be deflected. The pilot thus works only against the control forces of the tab, which are usually of small magnitude.

It is evident from the foregoing definitions that tabs may be divided into three general classes according to their uses: trimming, servo-control, and balancing. In addition, they may be inset, attached to, or mounted on outriggers from the trailing edge of the control surface. The inset type is usually preferred because of its simpler structure and also because comparative tests of inset and external tabs[1,2] have shown that the two types have about equal effectiveness.

Some Characteristics of Tabs

In this short paper it is impossible to go into any great detail concerning the characteristics of the various classes of tabs but some of the important features will be described.

Trimming Tabs

The *fixed* trimming tab may vary in width from 5 to 10 percent of the chord of the movable control surface

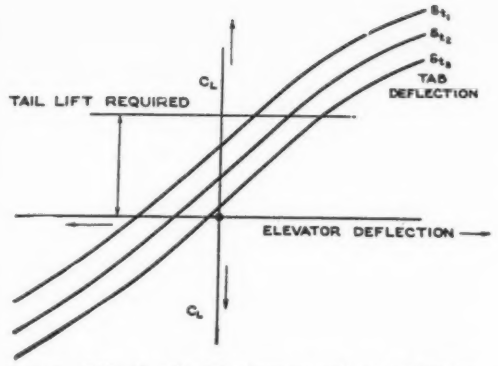

FIG. 2. Lift of tail with elevator and tab deflection.

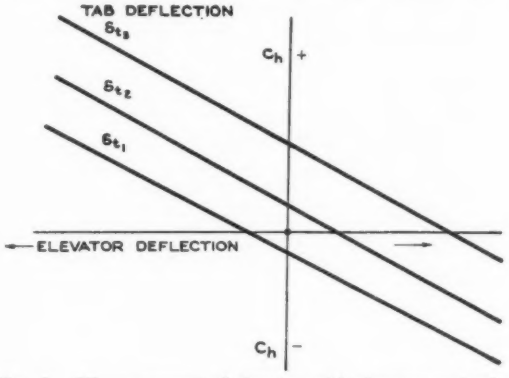

FIG. 3. Hinge moment of elevator with elevator and tab deflection.

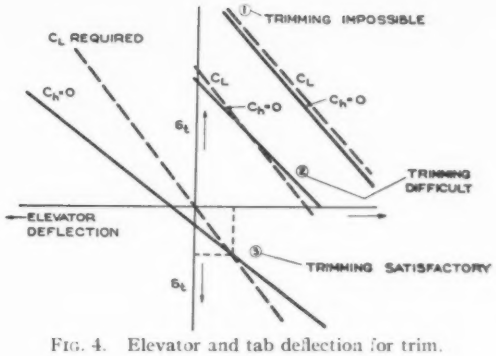

FIG. 4. Elevator and tab deflection for trim.

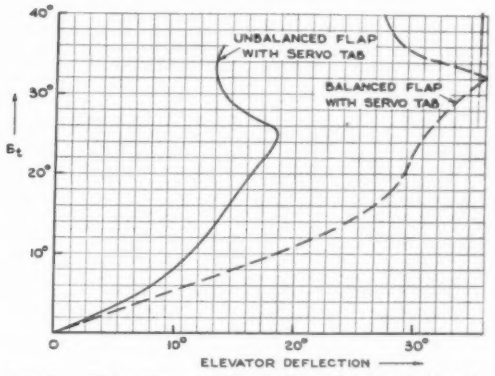

FIG. 5. Effect of servo tab on balanced and unbalanced flap.

and may have an aspect ratio ranging from 5 to 20. The usual procedure in practice is cut and try, with the aid of a pair of tin snips, until the smallest tab that corrects the existing dis-symmetry is obtained.

The *controllable* trimming tab is generally applied to the elevators and rudder and may vary in width up to about 25 percent of the chord of those surfaces. In connection with tabs it should be noted that the lift or side forces of the surfaces are appreciably modified when the tab is deflected. Consequently, comparison of different arrangements of tabs and control surfaces should take into account hinge moment, control deflection, the moment produced by the control surface, and the air speed.

A graphical method for the design of trimming tabs has been proposed by Lachmann and Stafford,[3] a brief description of which follows:

First, a large scale model of the tail unit is tested in the wind tunnel to obtain a series of curves of tail lift coefficient for various elevator and tab settings. The procedure should be repeated for several effective tail angles in order to cover the trimming range. Fig. 2 is a plot of tail lift against elevator deflection for three different tab settings. The line "C_L required" intersects the tail-lift curves at points that represent possible combinations of elevator and tab angles at which the airplane may be trimmed.

Second, elevator hinge-moments are obtained as functions of the elevator and tab settings and for the same effective tail angles. The data should be corrected for the weight moment of the elevator unless it is statically balanced. Fig. 3 shows elevator hinge-moment plotted against elevator deflection for three different tab angles. The hinge-moment curves intersect the abscissa axis at points that represent combinations of elevator and tab angles at which zero hinge-moment is obtained.

Third, two curves, which represent loci for the required tail-lift coefficient and for zero hinge-moment coefficient, are plotted as a function of tab and of elevator deflection (Fig. 4). The intersection between the two curves represents the only possible combination of elevator and tab angle that satisfies the two conditions combined. Satisfactory trimming is obtained when the angle between the two curves is not too acute; trimming is not possible if the curves are parallel.

Servo-Control Tab

The procedure just mentioned for trimming tabs may also be applied to servo-control tabs. In the case of very large control surfaces it appears desirable to balance the surface by some additional means such as the inset-hinge. The results of one use of this combination[4] are shown in Fig. 5 in which tab deflection is plotted against elevator deflection for both the

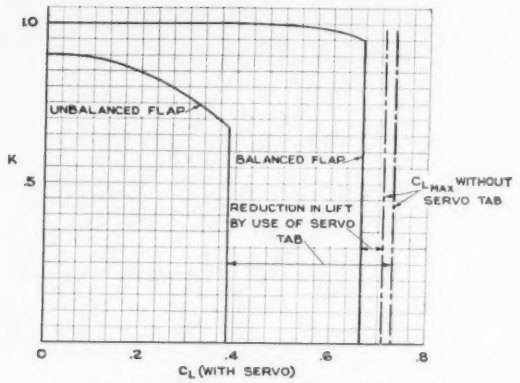

FIG. 6. Effect of servo tab on tail lift.

balanced and unbalanced control surfaces, each equipped with the same servo tab. It will be noted that a much greater deflection is obtained with the balanced surface than with the unbalanced surface for the same tab deflection.

When servo control is substituted for manual operation of the control surfaces, a considerable reduction in the maximum lift coefficient results for the case of the unbalanced arrangement but not nearly so much for the balanced arrangement. A comparison of the previously mentioned unbalanced and balanced combinations is shown in Fig. 6.[4] Here the ratio, K, of the lift coefficient for the surface with a servo-control tab to that without is plotted against the lift coefficient for the surface with a servo-control tab. It is immediately evident that the auxiliary balancing of the control surface is very desirable and, in the arrangement considered, an elevator with an elliptic leading edge and the hinge axis inset 30 percent of the main control-surface chord was found to be the most suitable.

The question of flutter of the servo-rudder system has been given some consideration in England[5] and has been the subject of considerable study. The most effective means of overcoming this objectionable feature appears to be mass balancing of the tab and mass balancing of the rudder[6] such that flutter will not occur when the tab is locked to the rudder.

Balancing Tab

The most effective width of tab for balancing purposes seems to be about 20 percent of the chord of the movable surface.[2] The span of the tab may vary up to 50 percent or more of the span of the control surface; the tab location along the span does not appear to be critical.

The ratio of tab deflection to control-surface deflection is an important factor in preventing overbalance; this fact is illustrated in Fig. 7. Elevator hinge-moment is plotted against tail lift coefficient for three conditions: tab neutral; tab deflection to elevator deflection of 2:3; and tab deflection to elevator deflection of 1:1. Fig. 7 shows that a ratio of 1:1 gives overbalance at low lifts; hence a desirable ratio is considerably less than 1:1 at low tail lifts and increases differentially with deflection.

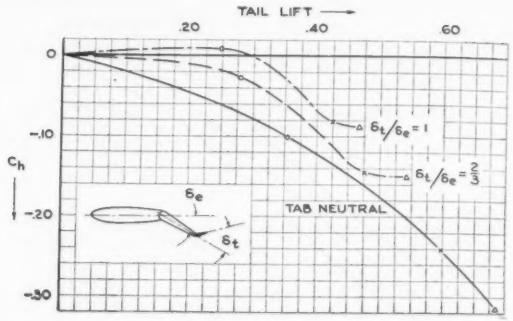

FIG. 7. Effect of tab-elevator deflection on hinge moments.

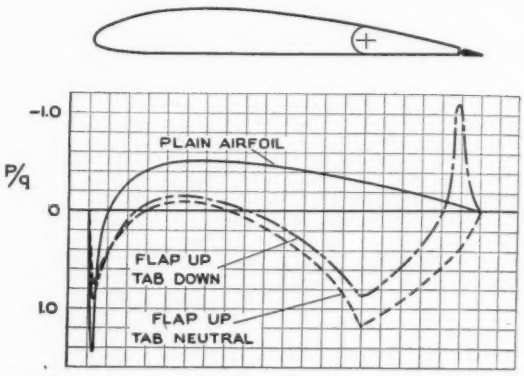

FIG. 8. Pressure distribution over airfoil with flap and tab.

It has been found that, in general, the balancing tab cannot be depended upon to give reductions in hinge moment for deflections greater than about $\pm 20°$. If further reduction in hinge-moment is required than can be effectively obtained with the balancing tab alone, then some other form of balance, such as the inset-hinge type, may be added. Tests have shown[2,4] that, if the hinge-moment is known for a control surface with paddle, horn, Frise, or inset-hinge types of balance, the further reduction due to the tab may be added directly to those hinge-moments.

Pressure Distribution on an Airfoil Section with Flap and Tab

The effects on the distribution of resultant pressure due to a flap, and to a flap with tab oppositely deflected, are shown in Fig. 8. These data were taken from recent tests in the N.A.C.A. 7 × 10 ft. wind tunnel.[7] Deflection of the flap alone produces peak pressures at the flap hinge; if the flap and tab are deflected simultaneously, peak values of the pressures occur at both hinge axes but the resultant pressures act in opposite directions.

Theoretical Considerations

Theoretical expressions have been derived by Perring[8] for calculating the lift, pitching moment, and hinge-moments for a thin airfoil with any multiple-hinged flap system. Experimental checks with the theoretical values have been made for a few cases[1,7] and fairly good agreement was found for the airfoil lift and pitching moments with small flap deflections, tab neutral. With the flap and tab both deflected, however, considerably smaller effects were obtained experimentally than were indicated by the theory.

Flap hinge-moments gave good agreement when the tab was neutral with respect to the flap, but with the tab and flap both deflected, only one-half to two-thirds of the theoretical effect is obtained. Hinge-moments of only the tab showed very poor agreement in all cases compared.

It does not, therefore, appear very feasible at the present time to predict, with sufficient accuracy, the characteristics of control surfaces with tabs from the theory alone.

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[4] Elliott G. Reid, *Servo Control Flaps*, Journal of the Aeronautical Sciences, Vol. 1, No. 4, pages 155–167, Oct., 1934.

[5] W. J. Duncan and A. R. Collar, *A Theory of Binary Servo-Rudder Flutter, with Applications to a Particular Aircraft*, R. & M. No. 1527, British A. R. C., 1933.

[6] W. J. Duncan, D. L. Ellis, and A. G. Gadd, *Experiments on Servo-Rudder Flutter*, R. & M. No. 1652, British A. R. C., 1935.

[7] Carl J. Wenzinger, *Pressure Distribution over an Airfoil Section with a Flap and Tab*, Report No. 574, N.A.C.A., 1936.

[8] W. G. A. Perring, *The Theoretical Relationships for an Aerofoil with a Multiple Hinged Flap System*, R. & M. No. 1171, British A. R. C., 1928.

Institute Meeting at Denver

THE Institute sponsored an aeronautical program at the Summer Meeting of the American Association for the Advancement of Science which was held at Denver, Colorado, on June 22.

The local chapter of the National Aeronautic Association was the host to the guest speakers. Charles F. Horner, President of the N.A.A.; F. W. Bonfils, Governor for Colorado and John H. Stark, President of the Rocky Mountain Chapter, arranged a program of entertainment which concluded with a barbecue for two hundred guests in the moonlight at eight thousand foot altitude in the mountains at Troutdale, thirty miles from Denver. After the barbecue, Dr. Clark B. Millikan expressed the appreciation of the Institute to Denver members of the N.A.A. for their hospitable attention and many courtesies.

The guest speakers were entertained at dinner at the Denver Country Club, after which a reception was given at the University of Denver.

Dr. Millikan, who presided at the meeting, introduced Mr. Horner, who told how glad the N.A.A. was to cooperate with the Institute in holding such an important aviation meeting in Denver. Major Gardner, Secretary of the Institute, presented his paper on "The Scope of Aeronautical Bibliography" by title, so that the other speakers would have more time to present their papers. He also expressed the appreciation of the Institute to the United Air Lines, who made it possible for several of the speakers to attend. He said that it was becoming easier to hold aeronautical meetings with outstanding speakers coming from coast to coast, as air transport made it possible for guests to assemble from all parts of the country without the loss of valuable time. As an illustration he mentioned that before noon of the day after the meeting, Professor Piccard would be in Minneapolis, Paul Richter, Vice-President of T.W.A., would be in Kansas City, Dr. Millikan would be in Pasadena, and he would be in Seattle.

It has not been possible to submit the papers given at the meeting to the Editorial Board of the Journal for their opinion as to publication, and, therefore, only digests are available at this time.

Professor Jean Piccard of the University of Minnesota presented a paper on "Composite Balloon Versus Single Balloon." An abstract of the paper follows:

"The sounding balloon goes about ten miles higher than the old free balloon. This is due to the fact that the sounding balloon is made from pure and very elastic rubber. The stress in it is very evenly distributed, while the free balloon is made from a rubberized non-elastic cotton cloth which allows no even distribution of the stresses. The free balloon must, therefore, be ten times stronger than the simple calculation of stresses would require. On the other hand, the very fact that the sounding balloon is made from an elastic material excludes the possibility of an open appendix. For this reason the sounding balloon will always go up till the inside pressure is sufficient to burst the envelope while the free balloon allows the excess of gas to escape through the open appendix. The free balloon for this reason reaches a position of equilibrium while the sounding balloon bursts at its ceiling.

"Since a single sounding balloon is able to carry a half pound instrument to an altitude of twenty miles it is obvious that two thousand sounding balloons could lift an air-tight gondola weighing a thousand pounds to the same lofty position. It is the intention of the author to construct such an assembly and to make scientific observations at the altitudes reached by sounding balloons.

"Before making such a flight the author intends to test the possibilities of the composite balloon by making, in the near future, an experimental flight with 80 sounding balloons attached to an open gondola."

H. M. Hucke, engineer in charge of United Air Lines communications laboratory, presented a paper on "The Elimination of Snow and Rain Static in Flying Operations." Mr. Hucke showed many interesting pictures of the experimental apparatus of the "flying laboratory" in which he and other technical specialists have been studying static effects in flight.

The former belief that static was caused by charged particles of ice, snow, rain, and dust striking the metallic surfaces of planes in flight has been disproved. Instead, it was learned that the atmospheric static heard in an air pilot's earphones is caused by the discharge from the trailing edges of the wings and tail surfaces of the static already gathered from certain cloud formations.

This new data has led toward development of a system of discharging the static from planes flying through the statically charged clouds in a manner which is expected to greatly moderate the electrical disturbance that causes difficulty in maintaining clear plane-ground communication.

The "flying laboratory," a regular twin-engined airliner converted for experimental purposes, had been fitted with special electrical and weather instruments. It flew almost daily for a period of three months in the western portion of the United States, its pilots searching out all varieties of cloud, snow, rain, and sleet conditions to gage the extent to which static interference is correlated with weather conditions.

Meterologists are analyzing studies which now indicate that bothersome static occurs only during certain conditions, and United Air Lines is planning to develop a system of forecasting major static areas on the airways and dispatch its planes around them, thus solving much of the static problem.

The first step toward the neutralization of the static discharges from the trailing edges of planes has already been taken. A static suppressed trailing discharge wire had been installed at the rear of the airplane with a resulting material improvement in the radio range reception during heavy static conditions.

The work on this discharge system was only started during the latter part of the expedition, and it is too early to evaluate its full significance. Many weeks of further investigation will be required before the system will be sufficiently perfected to install for regular use.

A machine for creating artificial atmospheric static was developed during the course of the experiments. The flying laboratory was placed on high voltage insulators and then charged with the synthetic static manufactured by the static machine. It was during the course of these experiments that the static suppressed dischargers were originated.

A new type of ice-free transmitting antenna insulator was de-

signed which will result in a material improvement of two-way voice communication.

W. A. Patterson, President of United Air Lines, said in his message to the Institute of the Aeronautical Sciences: "We are gratified by the information gained by the party of engineers with our flying laboratory. These research men have taken the mystery out of aircraft radio static and for the first time succeeded in clearly defining the problem. We now expect the eventual complete elimination of static troubles in our operation, before the coming winter season. The work of this group represents an important milestone in the persistent advancement of air transportation toward even greater air safety."

W. R. Gregg, Chief of the Weather Bureau, gave a paper on "Application of the Polar Front Theory to Practical Meteorological Forecasting." A digest follows:

"Much progress was made during the early years of weather forecasting by the Synoptic weather map, but, being empirical, a 'dead line' was reached two years ago in weather forecasting beyond which further improvement was not attainable.

"During this early pioneer period many theoretical investigations clearly established the fact that it is not the cyclones and anticyclones as such that are important in determining weather, but rather the interactions between the various air masses that go to make up those systems of high and low barometric pressure. These air masses from different source regions, polar, equatorial, continental, and marine, have different characteristics of temperature, humidity, and movement, and they tend to maintain their individual identities over comparatively long periods of time, with the result that at their surfaces of contact they form more or less marked discontinuities or "Fronts." It is along these frontal surfaces that the processes involved in weather phenomena are most active, and the study of them, now generally referred to as "air mass analysis," already has proved itself a powerful aid in developing forecasting along sound physical lines and is destined, we believe, in the not very distant future, to result in substantial improvement in the accuracy and precision of the forecasts and probably also in a moderate extension of the period covered by them."

Radio, codes, the teletype, and the airplane are now all contributing to gathering information on which to base weather predictions. Airplanes make flights twenty-five places in this country to secure weather data.

"Weather forecasts for 24 to 36 hours are not yet possible, but there are certain definite results already and they are all in the right direction. They show that our original plan to integrate the analyses and their applications to forecasting with the already existing forecast procedure and with the accumulated knowledge and experience in the past has, even in the short period thus far devoted to its development, made excellent progress in the forecast service at the Central Office in Washington. For nearly a year now the intermediate weather maps that have been analyzed in detail by the trained personnel of the air-mass section have been furnished as a guide for quick and reliable analysis on the principal morning and evening maps by the forecasters. The forecasters report that "this helps materially in readily locating the fronts and identifying the different air masses on these maps. Therefore, the forecasts are always expedited and at times are issued with more confidence because of greater assurance of a correct analysis of the current map.

"Paradoxically enough, the greater abundance of data which we seek will add to our difficulties in meeting one of the chief requirements of forecasts, that is, the necessity of issuing them promptly. We should have difficulty, for example, in justifying a service that could provide *perfect* forecasts three or four days after the period to which they apply! There must always be a compromise between as near an approach to perfection as possible and the practical needs that we are endeavoring to meet.

"The really important thing is that we are now developing our forecast service along sound physical lines, supplementing at present as far as possible, and ultimately, we hope, largely replacing, the empirical methods that have heretofore been employed. Genuine progress already has been made, but we believe that it marks only the opening chapter."

Fred D. Fagg, Director of Air Commerce, spoke on the "Federal Control of Air Traffic." As Mr. Fagg spoke extemporaneously, no digest of his paper was available. He discussed the increasing difficulty of handling air traffic, particularly at airports where many arrivals and departures of transport airplanes come within a short period, particularly in bad weather. He also told of the difficulty of permitting private fliers who did not have adequate communication equipment to use air terminals.

Fowler W. Barker, Secretary of the Air Transport Association of America, presented a paper on "Contributions of Science to Air Transport."

"It is believed to be a fact that aviation is directly interested in more sciences than is any other industry. Among these are: Astronomy, Bacteriology, Chemistry, Ceramics, Economics, Education, Entomology, Geology, Mathematics, Medicine, Metallurgy, Mineralogy, Meterology, Philology, Philosophy, Physiology, Photology, Physics, Psychology, Radio, and Sociology. There are many other branches of learning than these, of course, in which air transport is interested indirectly."

Mr. Barker then explored each field of the above sciences giving instances of the relationships between the various sciences and air transport.

Others who were present were Paul Richter, Vice-President in Charge of Operation, T.W.A.; Marvin W. Landis, Vice-President, Wyoming Air Lines; Frank Caldwell, Chief Dispatcher, United Air Lines; Col. T. DeWitt Milling; Reeder Nichols; Ford Studebaker of the Bureau of Air Commerce; O. T. Larson, United Air Lines, and Fred Kreuger, Denver Manager, United Air Lines.

Institute Notes

Honors

Several members of the Institute received honorary degrees during June. Samuel S. Bradley, Chairman of the Board of Directors of the Manufacturer's Aircraft Association, was given the degree of Master of Science by the University of Michigan; George J. Mead was given the degree of Doctor of Science by Trinity College; Willis R. Gregg, Chief of the United States Weather Bureau received the degree of Doctor of Science from Norwich University. At the same time, Colonel Edgar S. Gorrell, President of the Air Transport Association of America, who, although not a member of the Institute, has many friends among its members, also had the degree of Doctor of Science conferred on him by Norwich University.

Necrology

R(eginald) J(oseph) Mitchell, an Associate Fellow of the Institute, died in Southampton, England, on June 11, at the age of 42. At the time of his death he was Director and Chief Designer of the Supermarine Aviation Works which has its aircraft factory in Southampton. Mr. Mitchell's greatest achievement was the designing of a series of successful Schneider Trophy seaplanes. He visited the United States during these races and his many friends here will regret the loss of such a delightful friend and brilliant engineer.

In 1920 he produced the original "Southampton flying boat" for the Royal Air Force and later designed the Scapa and Stranraer types.

Born in Stoke-on-Trent, he served his apprenticeship in the locomotive building firm of Kerr, Stuart & Co., and entered aircraft construction in 1916 with Hubert Scott-Paine. He was thus one of the pioneers of seaplane building.

Many of the most famous British speed planes were the product of Mr. Mitchell's designing board. At the Air Ministry competition in 1920 his "Supermarine amphibian flying boat" won second prize. Two years later his Sea Lion won the Schneider Trophy. A second Sea Lion was entered the following year, but only reached third position.

Among the ships he designed was the Seagull, an amphibian which was also used for deck landing. Among the racing ships of his design the S4, S5, S6, and S6B have set record speeds.

The S5 won the Schneider Trophy in 1927, the S6 in 1929, and the S6B in 1931. The latter was flown at a speed of 340.08 m.p.h., and later established a world's record, since broken, of 408.8 m.p.h.

Mr. Mitchell was the author of several articles on speed plane design and was the recipient of the Distinguished Flying Cross. He was a Companion of the British Empire, and a Fellow of the Royal Aeronautical Society of London.

Student Branches

University of Michigan. A final meeting for the academic year 1936–37 was held by this Student Branch on the evening of May 27. This meeting was the first following the installation of the new officers for the year 1937–38 and was conducted by the new Chairman, Jere Farrah. B. L. Springer, Instructor in the Department of Aeronautical Engineering, who had attended the Twelfth Annual Aircraft Engineering Research Conference at Langley Field, was the first speaker of the evening. He described some of the research work now being conducted at the laboratories, the problems involved, etc. Prof. F. W. Pawlowski, the next speaker, discussed the experiences which he had had during the spring vacation period. He also discussed his visit to the Budd factory at Philadelphia where a new type wing of stainless steel, all shot-welded, has been developed. The meeting was adjourned at 9:30.

University of Minnesota. At a meeting of this Student Branch on May 27, the following officers were elected for the school year of 1937–38: Bertil H. T. Lindquist, President; Robert Moore, Vice-President; Robert J. Schoonmaker, Secretary; Jack Mace, Senior Class Representative; and Don Lampland, Junior Class Representative.

New York University. At the final meeting of this Student Branch for the academic year 1936–37, elections were held for the coming school year 1937–38. The following officers were elected: Frederick C. Phillips, Chairman; Richard Berne, Vice-Chairman; and John B. Reese, Secretary-Treasurer. The new Honorary Chairman will be Everett B. Schaefer, who lectures on airships, the aeronautical laboratory, and on propeller design.

Rensselaer Polytechnic Institute. The executive committee of this Student Branch of the Institute held a meeting on Friday, May 28, at which the activities for the coming year were discussed. The Program, Membership, and Publicity Committees were appointed, and the question of speakers for meetings, etc., were discussed.

Book Review

Sky Storming Yankee, by Clara Studer; Stackpole Sons, New York, 1937; 370 pages, ill., $3.00

The life of Glenn Curtiss is well worth a book. He was one of the great pioneers of aviation and he had a career that the average person likes to read about. But Miss Studer's treatment of his career leaves much to be desired.

To those who were not engaged in aeronautics during the early period of which the book treats, this biography appears to have been written as a result of research and careful investigation. The publishers claim that the facts were "carefully checked and rechecked." But when the book is submitted to those who are in a position to appraise the worth of the book, the resulting comment is extremely critical and would create a controversy which has no place in a technical publication.

It is well known that Glenn Curtiss did everything in his power to prevent the publication of his biography during his lifetime. Four or five attempts to write the story of his life were made by friends or ambitious writers but they were all stopped. Friends of this great pilot resent this author's presenting Curtiss to the public as having no early interest in aviation until Dr. Alexander Graham Bell offered to pay him twenty-five dollars a day and his expenses.

What arouses perhaps the sharpest rejection is the part of the book in which the Smithsonian Institution controversy with the Wrights is discussed. Miss Studer gives the impression that the testing of the Langley machine originated in the mind of Dr. Walcott, Secretary of the Smithsonian Institution, and that only after the first tests were made did Curtiss and his counsel, Judge Crisp, conceive the idea of making further tests for use in the patent suit which was pending between Curtiss and the Wrights.

The gratuitous attack made on Griffith Brewer, who is referred to as "Gilbert Brewer," the distinguished English pioneer and the first Englishman to fly as a passenger in an airplane, will be resented both here and in England.

Another commentator on the book has questioned about ten of the "firsts" credited to Curtiss, but many of these have always been controversial. If a reader will overlook frequent partisan passages throughout the story, he still will have left a valuable record of the important facts in the life of Glenn Curtiss which belong in any history of aviation.

AERONAUTICAL REVIEWS

These brief reviews of recent articles on aviation subjects are published by the Army Air Corps for the information of its officers, and are printed here each month by permission of the Chief of the Air Corps.

Aerodynamics

Method of Smoke Strips for Studying Flow of Air Around Obstacles. J. Valensi. Smoke is emitted either in form of a continuous jet at speed of the air current or in a discontinuous and periodic manner by small puffs of controllable frequency, and is observed stroboscopically at the flash of a Stroborama and continuously by laminar lighting. Results described cover: field around an airplane propeller; flow around airplanes; measurement of circulation around different sections along a propeller blade; trajectories in the propeller field; phenomena in vicinity of wing-fuselage attachment of a low-wing monoplane: flow around tail surfaces and influence of propeller slipstream for a single-engined low-wing monoplane; marginal phenomena of airplane wing; and stability. L'Aeronautique, Supplement, February, 1937, pages 17–26, 27 illus., 1 table.

The Part Played by Skin Friction in Aeronautics. F. W. Lanchester. Correction to data in recent paper on conditions that obtain at low Reynolds number. Jour. Royal Aeronautical Soc., April, 1937, pages 322–323, 1 illus., 2 tables.

Profile Drag. B. M. Jones. Factors controlling profile drag, especially skin friction of the wings. Laminar and turbulent boundary layer, viscous sublayer, aerodynamically smooth surfaces, typical values of skin friction and boundary-layer thickness, and factors determining the point of transition to turbulent flow are discussed. Experimental methods for flight measurements of the profile drag of a wing or any part of it, and for locating the point of transition from laminar to turbulent flow in the boundary layer, and an arrangement for measuring profile drag by the pitot transverse method, are described. Discussions by F. W. Lanchester, W. S. Farren, and others, and the author's reply included. Jour. Royal Aeronautical Soc., May, 1937 pages 339–368, 20 illus.

Aircraft Design

Longitudinal Stability. W. R. Andrews. Loading of biplane wings, and procedures for determining downwash at the tail plane for monoplane and biplane, and lift due to the tail plane. Continued. Flight, Aircraft Eng Supplement, April 29, 1937, pages 25–28, 8 illus., 7 tables, many equations.

The Natural Limits to Human Flight. H. E. Wimperis. Discussion covers: limits to very high speeds set by engine power and airplane drag; effect of increasing speed on the power of maneuver with special reference to the power dive and taking into account the endurance limit of both the human body and the airplane itself; conditions limiting altitude; and dependence of range on size of aircraft, engine power, and height. Royal Aeronautical Society paper. Engineer, April 30, 1937, pages 505–507, 4 illus.

Editorial criticism of paper. Flight, April 29, 1937, pages 405–406.

On Venetian Blind Landing. C. G. Grey. Suggested combination of Venetian blind, made of slats of airfoil section, with a retractable undercarriage. When the undercarriage is folded up the slats are to lie flat along the bottom of the fuselage and underside of the wings, but when the undercarriage is pulled down it is considered that a multitude of airfoils will not only set up terrific head resistance and act as a useful air brake but might give considerable lift. Development of slots and flaps is traced and reference made to various patents. Handley-Page Hampden illustrated. Aeroplane, April 28, 1937, pages 499–504, 12 illus.

Recent Progress in the Design of Civil Flying Boats. A. Gouge. Progress in the last eight years is traced by an account of the author's experiences in designing Calcutta, Kent, and Empire flying boats for Imperial Airways. Design data, tank-test results, and performance obtained in actual operation of these airplanes are compared. Long article with reference also to military types and to future trends. Jour. Royal Aeronautical Soc., April, 1937, pages 257–273 and (disc.) 273–283, 11 illus., 4 tables. (See also Part V—Air Warfare for Proposed Designs of Military Aircraft.)

High Altitude or Stratosphere Flying. Group-Captain E. W. Stedman. Discussion on aircraft requirements includes: effects of change of fineness and loading and of altitude upon airplane performance; speed limitations; refinements in aerodynamic features; problems in cabin design in regard to super charging, pressure regulation, emergency equipment, water vapor and CO_2, and cabin insulation; controls and instruments; load factors; and deicing equipment. Power variation with altitude, geared, Roots-type and exhaust-driven superchargers, engine cooling, magnetos and insulation, fuel and ozone effect, and batteries are taken up in the engine section, and propellers briefly discussed.

First section considers composition of the atmosphere, air temperature and pressure, and winds in the stratosphere; the second, adaptability of the human machine to conditions (respiratory system, anoxoemia, amount of air required, angle of tilt, and rate of climb). Final section covers the flight path and lists unfavorable and favorable factors towards realizing stratosphere flights within the next few years. Engineering Institute of Canada paper. Author is Chief Aeronautical Engineer of the Royal Canadian Air Force. R.A.F. Quarterly, April, 1937, pages 147–171, 7 illus., many equations.

How High? N. B. Moore and W. C. Rockefeller. Two factors determining the ultimate ceiling to be obtained by aircraft, namely thrust horsepower available and the drag. Variation of absolute ceiling with parameter, and relation of absolute ceiling with span, power, parasite drag, and weight are illustrated. Aviation, May, 1937, pages 28–29, 75, 4 illus.

Notes on the Design of Aeroplanes for Attaining High Altitude. Captain F. S. Barnwell. Design of a conventional single-engined airplane to achieve greatest possible altitude. Engine is assumed to give 345 b.hp. at 50,000 ft. and 210 b.hp. at 60,000 ft. and to have a net dry weight of 1250 lb. Estimate of the fixed weights of airplane, suggested layouts for low-wing monoplane with 7–1 aspect ratio, and biplane of equal wings of 8–1 aspect ratio, weights of airframe structure for both types, drags, propeller slipstream, densities and speed factors, thrust horsepower, and propeller are considered. Jour. Royal Aeronautical Soc., April, 1937, pages 306–321, 6 illus., 4 tables, many equations.

At High Altitude. F. W. Lanchester. Relation between optimum condition, as determining the design for least resistance, and the condition of least resistance for a machine "in being" is explained. Constant-span graphs show the relation of velocity to altitude and a method is demonstrated by which graphs of constant power are evolved. A chart for a hypothetical airplane (4 tons gross weight and aspect ratio = 10) is given in which altitude, velocity, optimum span, and net thrust horsepower are represented, from any given two of which the other two can be determined. To be continued. Jour. Royal Aeronautical Soc., May, 1937, pages 388–400, 8 graphs.

"Chord Flaps." Marendaz system of increasing lift and drag. The flaps are hinged to the rear spar far enough ahead of the trailing edge so that ordinary ailerons can be retained behind the flap, thus making it possible to use full span flaps if they prove desirable. In the closed position, the flap rests in a recess in the under side of the wing. As the flap opens, a slot forms, owing to the forward location of the hinge line, the slot width increasing with flap angle. Flight, May 13, 1937, page 478, 3 illus.

The Limits of Flight. "Mr. Wimperis is concerned with the limits of flight, not with the performance of aircraft in general, and it begins to look as though the boundaries he predicts—a speed of 600 m.p.h., and altitude of 61,000 ft., and a range of 12,500 miles—will not be fixed by human limitations of either physiology or enterprise." Editorial on "The Natural Limits to Human Flight", presented by H. E. Wimperis before the Royal Aeronautical Society. Engineering, May 21, 1937, pages 583–584.

Theoretical Determination of Air Forces and Moments on Wings. W. H. Miller and P. M. Magruder. Determination of the lift distribution when the geometrical angle of attack distribution is given. Discussion of the fundamental concepts of Dr. Munk and others is continued from the January issue. Aero Digest, May, 1937, pages 52, 75–77, 1 table, 11 equations.

Stress Analysis and Structures

Cantilever Plate with Concentrated Edge Load. D. L. Holl. Problem of a finite length of a cantilever plate which bears a concentrated load at the longitudinal free edge is solved approximately by the method of finite differences. All boundary conditions are taken into account and plate action is determined approximately at all points of the plate. Jour. Applied Mechanics, March, 1937, pages A8–A10, 3 illus., 1 table, 10 equations.

Down Gusts. J. H. Crowe. Adequacy of present British airplane strength requirements for up-and-down gusts is questioned, and a plea is made for a modification so that the lightly loaded condition of the airplane can be specifically cared for. Available data concerning magnitudes of down gusts are reviewed, and the sharp-edged gust hypothesis briefly examined. British requirements are compared with those of the I. C. A. N. and United States. Editorial included. Aircraft Engineering, May, 1937, pages 119–122 and 117–118, 5 graphs, 2 tables, 16 equations.

The Effect of Initial Curvature. J. Morris and W. Tye. Method given in "The Stressing of Rigid-Jointed Frames" (Journal Royal Aeronautical Society, June, 1936) is applied to the case of frames embodying initially curved members, such as monocoque rings. Aircraft Engineering, May 1937, pages 123–125, 3 illus., 3 tables, many equations.

Contribution to the Theory of the Incomplete Tension Bay. E. Schapitz. For a sheet stressed as to shearing and compression directly after buckling, stress distribution is still irregular and the second principal stress should not be neglected. This condition is designated as the "incomplete tension bay" and is described by the theory given for the general case of compound stresses and elastic stiffenings. Behavior of the buckled sheet is defined by two characteristic values, one of which represents stress distribution and the other geometric deformation in the case of curved sheets. Variability of the characteristic values according to stresses and deformations should be determined through tests. DVL report. Luftfahrtforschung, March 20, 1937, pages 129–136, 9 illus., 1 table, 21 equations.

Different Methods of Wing Construction. Wing construction used in various countries. Ten examples given by M. Lachmann. Les Ailes, March 18, 1937, page 7, 12 illus.

Effect of Rivet Spacing on Compressive Strength of Stiffened Duralumin Shells. A. Kromm. Influence of rivet spacing in stiffened shells on the stress bearing of the skin, on elastic mounting of the longitudinal stiffeners, and on the buckling tendency in the longitudinal stiffeners due to skin folds. Rivet spacing was varied between 20 and 70 mm. For profiles with double rivet rows the effect of staggered riveting was determined at 3 mm. spacing. DVL report. Luftfahrtforschung, March 20, 1937, pages 116–120, 9 illus. 5 tables.

Revision of Strength Specifications for Airplanes. A. Neison and A. Teichmann. German strength specifications of January, 1935, and revisions made in August and December, 1936. New requirements for factor of safety, performance tests, and applied air, ground and water forces, as well as strength determination are discussed. Luftwissen, February, 1937, pages 43–52, many equations.

The Solution of Continuous Girders by the Relaxation Method. H. J Hopkins. "Stress Calculation in Frameworks by the Method of Systematic Relaxation of Constraints," by Professor Southwell is referred to and the problem of continuous girders in which the supports sink under load is solved by relaxation methods. Engineering, April 23, 1937, pages 469–472, 4 illus., 5 tables.

Stability of Orthotropic Elliptical Cylindrical Shells in Pure Bending. O. S. Heck. Theoretical critical bending stress of elliptical cylindrical shells determined on the supposition that shells are infinitely long and that local phenomena of instability do not occur. Test results on isotropic elliptical cylindrical shells stressed as to bending are compared with theoretical values, and practical application discussed. DVL report. Luftfahrtforschung, March 20, 1937, pages 137–147, 19 illus., 3 tables, 59 equations.

The Stress Bearing Width of the Plate in Compression. K. Marguerre. Practical simplified calculation for test results published in an article entitled "Bearing Strength of a Sheet Strip Stressed Beyond the Buckling Limits" (Z. angew. Math. Mech., 1937). The method is further developed for use in airplane design, and a theoretical proved formula for the stress bearing width beyond the buckling load is obtainable. DVL report. Luftfahrtforschung, March 20, 1937, pages 121–128. 3 illus., 53 equations.

Theory and Tests on the Strength of Monocoque Fuselages. H. Ebner. Determination of stress condition (shell statics) and resistance to fracture, (shell strength) of monocoque fuselages. Most important theoretical and test results, particularly those obtained by the DVL, are discussed and a summary of various monocoque types given. DVL report. Luftfahrtforschung, March 20, 1937, pages 93–115, 40 illus., 4 tables, many equations.

Some Methods Used in the Static Testing of Aircraft Structures. E. W. Walker. Static testing of wing ribs is explained in greater detail and methods used in static testing of ailerons, wing flaps and tabs, and control systems are dealt with. Dynamic testing of tail wheels and landing gears also described. Continued. Aero Digest, May, 1937, pages 30–31, 7 illus.

Stresses in Symmetrically Loaded Hemispherical Shells Having Tapered Edges. S. C. Hollister. When a thin hemispherical shell is fixed at the edge and subjected to internal pressure, bending stresses are set up in a meridional element near the shell edge. Methods of solving for stresses in a shell with a thickened periphery when the shell is subjected to internal pressure and fixed at its edge, is only partially restrained at its edge, or is loaded symmetrically to its axis of rotation but in a manner other than by internal pressure, are described. Jour. Applied Mechanics, March, 1937, pages A11–A15, 5 illus., 1 table, 39 equations.

Theory of Flexure Applied to the Analysis of Wings of Box Type Construction. G. L. Bryan. Application of the general theory of flexure to the design of one wing section of the Martin China Clipper. Bending stresses and neutral axis location are determined for the high and low angle-of-attack loading conditions. Aero Digest, May, 1937, pages 36, 38, 40, 3 illus., 3 tables, 10 equations.

The Torsionless Bending of a Hollow Beam by a Transverse Load. W. L. Schwalbe. When bending is caused by transverse loads, shearing stresses and strains in the cross sections are necessary, and a particular longitudinal section remains plane only if the resultant of the shearing stress, and hence the plane of the applied bending moment, possesses a particular location. Location of this resultant shearing stress is determined by a method based on St. Venant's theory. Jour. Applied Mechanics, March, 1937, pages A25–A30, 11 illus., 44 equations.

Aircraft

With the Foreign Builders. Italian Jona J-6 airplane with upper wing hinged laterally to the tiltable automatically or by the pilot, transatlantic flight of the German Ju-86 Diesel-powered Junkers plane, and the new German Focke-Wulf FW 58B Weihe twin-engined observation and bombardment training plane. Few details. Aviation, May, 1937, pages 45–46, 2 illus.

AUSTRIA

Two Hirtenberg Prototypes. Two military planes of Austrian manufacture. The H.M.-15 two-engined light bomber-trainer has a top speed of 240 km. per hour. The H.M.-11 amphibian is powered by two Walter Bora 250-hp. engines and weighs 2250 kg. in flight with three men, 200 kg. of bombs, two machine guns with 1000 projectiles, and fuel for a radius of operation of 500 km. Characteristics and performance of the former. Rev. de l'Armée de l'Air, March, 1937, pages 352–354, 6 illus.

FRANCE

Cool Calculation. Specially-equipped Caudron Typhon single-seater with which Prince Cantacuzene intended to reach the Cape from England in 29 hours. Two drawings of cockpit showing location of instruments. Flight, May 6, 1937, page 464, 3 illus.

Accident to the Varivol. J. Gerin. Long discussion of an accident to the Gerin variable-surface airplane in which the pilot was killed. L'Aeronautique, February, 1937, pages 23–26, 5 illus.

Latécoère 582 Reconnaissance and Bombardment Flying Boat. Flying boat equipped with three Gnôme-Rhône 14-Kirs 740-hp. engines has reached a speed of 275 km. per hour at 1500 meters and 279 at 2180 meters. Photo only. Les Ailes, April 8, 1937, page 3, 1 illus.

Loire-Nieuport 161 Pursuit Airplane. A. Frachet. All-metal monoplane with good visibility is equipped with a Hispano-Suiza 12Ycrs "moteur-cannon" (860 hp. at 4000 meters) and has a maximum speed of 480 km. per hour at that altitude. Long description. Les Ailes, April 22, 1937, page 6, 2 illus.

New Airplanes in Tests. Morane-Saulnier 430 pursuit trainer, Loire-Nieuport 20 general-purpose, and the Loire 21 pursuit seaplane are briefly referred to in the first issue, and the Caudron-Renault C-690 pursuit trainer and the Latécoère 298 torpedo seaplane (speed around 300 km. per hour) in the second. Les Ailes, April 8 and 22, 1937, page 10.

Technical Notes. Flying model of the Wibault 25-ton 5000-hp. transport is equipped with four 20-hp. engines, will be tested in the Chalais-Meudon wind tunnel and then flown by proper means as a popular sport plane. Brief reference. Les Ailes, April 1, 1937, page 7. Monoplane with tandem wings developed by M. Delanne. Few details. Les Ailes, April 22, 1937, page 6.

Volland V-10 Light Airplane. A. Frachet. Two-place training, touring and acrobatic biplane equipped with a 60-hp. Train engine has a range of 1000 km. at a cruising speed of 140 km. per hour. Long description. Les Ailes, April 8, 1937, page 6, 3 illus.

GERMANY

A Metal-Clad Invader. German Messerschmitt 108 Taifun four-seater (240-hp. Argus aircooled hanging vee engine) to be sold in England. Maximum speed is 186 m.p.h. Long description, cutaway drawings, photographs.

Performance described in a second article. Aeroplane, May 5, 1937, pages 537–539 and 550, 10 illus. Flight, May 6, 1937, page 457, 2 illus. (Performance and control layout.)

A Seaplane for the Atlantic. Hamburger Ha-139 all-metal 16-ton four-engined twin-float catapultable seaplane recently built for Deutsche Lufthansa for transatlantic mail service. Monoplane wing is in the form of a W and is built up around a single tubular steel spar of large dimensions which serves as a fuel tank. The seaplane is equipped with four Junkers Diesel Jumo 205-C 600-hp. engines and has a top speed of 186 m.p.h. Description of seaplane and few details of the Friesenland depot ship. Aircraft Engineering, May, 1937, page 136, 2 illus.

GREAT BRITIAN

1911–1937. Progress in British aircraft design from the coronation of George V to the end of the war period, covering records, aircraft firms, twin-engined airplanes, early designs, and war-time development of military and marine airplanes. Long detailed review. To be continued. Flight, May 6, 1937, pages 434–446 and 463, 38 illus.

Aircraft Militant, 1919–1937. Design of British military aircraft from the demobilization after the war up to the expansion program, including single-seater fighters, single-engined multi-seater light bombers, army cooperation and general-purpose aircraft, multi-engined landplanes, fleet and marine types, and torpedo carriers. Caption for photograph of the Merlin-engined Supermarine Spitfire states that it is the fastest military airplane in the world. Flight, May 6, 1937, pages 446a–446d and 447, 12 illus.

By Official Precept. Menter I is the R.A.F. version of the Miles Nighthawk. Brief reference. Aeroplane, May 5, 1937, page 526.

Chiaroscurists with Colour. "Shadow shading" a Handley-Page Harrow heavy bomber. Photograph only. Flight, May 13, 1937, page 473, 1 illus.

The Civil Side. Development of British commercial and private aircraft since the war. Long review. Flight, May 6, 1937, pages 448–451, 7 illus.

The Cygnet Flies. Control system of the C. W. Cygnet Minor all-metal stressed-skin side-by-side cabin monoplane. Brief descripton. Flight, May 13, 1937, page 481, 3 illus.

The Four Winds. Hawker Hart fitted experimentally with Bristol Mercury VIII engine and gilled cowling does 209 m.p.h. at 15,550 ft. and climbs to 17,000 ft. in 7 min. 7 sec. The Hart has been used for comparative tests of this installation and a Mercury VI with Townend ring. Brief reference. Flight, May 13, 1937, page 473.

The Hafner Gyroplane. New type of gyroplane capable of vertical take-off and descent. Rotor blades are driven directly by the engine and are fitted with a variable-incidence mechanism. Few details of gyroplane shown at the Royal Aeronautical Society's garden party. Engineer, May 14, 1937, page 555.

Long description of construction and controls of the A.R. III with drawings. Engineering, May 28, 1937, pages 600–602, 11 illus., 7 on supplement plates.

Practical Ideal. Moss light cabin monoplane powered by a Pobjoy Niagara III 95-hp. engine, carrying a useful load of 400 lb., and having a range of 400–500 miles. Few details. Flight, May 13, 1937, 3 illus.

The R. Ae. S. Garden Party. Account of the Royal Aeronautical Society's annual garden party describing flight demonstrations and the "static" display of aircraft, accessories, instruments, and engines. Flight, May 13, 1937, pages 468–471, 10 illus. Aeroplane, May 12, 1937, pages 557–558, 5 illus.

A Recent Development in Aircraft Construction. Clyde Clipper high-wing strut-braced all-metal monoplane being produced by the Scottish Aircraft and Enginering Company under Burnelli patents. Constructional methods adopted and outline of estimated weights, performance figures, and characteristics. Engineer, May 21, 1937, pages 591–594, 19 illus.

The Technical State of British Aviation. T. James. Technical position of British military and civil aircraft at present. Details of the military airplanes, seaplanes, and flying boats in service and new developments are given, including a description of the slots and flaps on the Westland Lysander Army cooperation monoplane. Aeroplane, May 12, 1937, pages 577–584, 17 illus.

British Commercial Aeroplanes. Drawings, photographs, and few details of 17 British commercial airplanes and of seven planes marketed in England. Table gives charcteristics and performance of British transport airplanes. Aeroplane, April 21, 1937, pages 466–474, 48 illus., 1 table.

An Illustrated History of Service Aircraft. Sopwith "Camel" F-1, Sopwith triplane, Vickers "Gun Bus" F.B.5, F.E.2d, R.E.8, S.E.5A, Bristol Fighter F.2B, and the DeHavilland 9. Description, drawing, squadrons which were equipped with these planes, principal dimensions and performances. To be continued. R.A.F. Quarterly, Supplement, April, 1937, 16 pages, 8 illus.

Improved Performance. Estimated figures for the Scottish Aircraft Clyde Clipper have been exceeded by calculations for the new model, the BR-Mark II 14 to 20-passenger transport. With two fully-supercharged Rolls-Royce Kestrel XVs, the airplane should have a range of $6^1/_2$ hours at 216 m.p.h cruising speed. Brief reference to characteristics. Aeroplane, April 28, 1937, page 523.

Survey Special. Special features and equipment of the B.A. Double Eagle being built for air survey work in Africa. Redesigned windshield to provide the pilot with a better range of vertical visibility, arrangement of tanks, special controls and their operation, installation of the Smith three-axis automatic pilot, and special heating and ventilation system are described. The latest type of Series II Gipsy Sixes with D.H. variable-pitch propellers give a cruising speed of about 160 m.p.h. at 16,000 ft. with an endurance of five to six hours. Placing of the trimmer on a large type of airplane is thought never to have been attempted before. Flight, April 29, 1937, pages 422–423, 2 illus.

Cutaway drawing showing location of special equipment, especially that of the Smith automatic Triune pilot and Williamson Eagle camera which takes vertical photographs through the floor or obliques through the removable Perspex windows. Aeroplane, April 28, 1937, page 496, 1 illus.

Up for "Schools". Airspeed Oxford twin-engined advanced training monoplane now in large-scale production for the R.A.F. and fitted with an Armstrong-Whitworth gun turret. Drawings and reference to military uses. Flight, April 29, 1937, page 421, 1 illus.

The World Altitude Record. Bristol high-altitude airplane in which Squadron-Leader F.R.D. Swain reached a height of 49,967 ft. on September 28, 1936. Previous world altitude records, design considerations, and details of airplane, engine, and special equipment. R.A.F. Quarterly, April, 1937, pages 172–177 and 180, 2 illus., 1 table.

Photographs Only. D.H.91 Albatross experimental airliner or bomber, which may be used for transatlantic experiments. The airplane has four D.H. Twelve motors of about 500 hp. each, is estimated to weigh 25,000 lb. and to do 250 m.p.h. Aeroplane, April 28, 1937, page 497, 2 illus. Flight, April 29, 1937, page 413, 3 illus.

Mr. Miles' latest slotted flap idea in which the two "Venetian blinds" appear to have a differential motion relative to one another. Wing only is illustrated. Flight, April 22, 1937, page 401, 1 illus. Aeroplane, April 21, 1937, page 453, 2 illus.

Vickers-Supermarine Stranraer used for reconnaissance, bombing and torpedo transport (not dropping) has a maximum speed of over 160 m.p.h. and is fitted with two 850-hp. Bristol Pegasus Xs. The Vickers Wellesley, originally built to a general-purpose specification, is classed as a medium bomber. Flight, April 22, 1937, pages 392–393, 4 illus.

Vickers Wellesley (960-hp. Bristol Pegasus) long-range bomber now in production. Aeroplane, April 21, 1937, page 455, 1 illus.

HOLLAND

Two-Seater Koolhoven FK-52. General-purpose fighter powered by a Bristol Mercury 830-hp. engine and having a maximum speed of 230 m.p.h. Construction, equipment, specifications, and performance. Aero Digest, May, 1937, page 89, 1 illus., 1 table.

Fokker F-56: A New Transport. Medium-wing two-floor monoplane of 38.5 meters span 200 square meters surface, 15,250 kg. weight empty, and 22,500 kg. loaded. Equipped with four Hispano-Suiza 14-Ha 1120-hp. engines, it should attain 355 km. per hour maximum speed. Few details and illustration of airplane model exhibited at Stockholm. Les Ailes, April 8, 1937, page 8, 1 illus.

ITALY

C. A. N. T. Z-1.001. Italian bomber, designed by Zappata, is constructed entirely of wood and has a maximum speed of 370 km. per hour at 4500 meters. Photograph only. Les Ailes, April 8, 1937, page 11, 1 illus.

C. A. N. T. Z-506 Transport Seaplane. A. Frachet. Cant Z-506, after breaking new world records, has been placed in the service of the Ala Littoria airline where it transports twelve passengers, a crew of four, and express at 320 km. per hour over 1300 km. The seaplane is powered by three A5 R-G. 770-hp. engines. Long description. Les Ailes, April 1, 1937, pages 1 and 6, 6 illus., 2 tables.

New Italian Aircraft. New aircraft ordered for a high-speed air service between Rome and Addis Ababa will have four 1000-hp. engines, accommodations for 50 passengers, and about 30 tons of cargo and will be capable of flying the 2800 miles in a little over twelve hours. Brief reference. Engineer, April 23, 1937, page 479. Flight, April 22, 1937, page 389.

This Week's Italian Record. Cant Z.508 flying boat fitted with three Isotta-Fraschini engines and carrying a load of 10 tons was taken by Stoppani to 4863 meters. The Asso XI RC.40 engines give 836 hp. at 13,000 ft. at 2250 r.p.m. Brief reference. Flight, April 22, 1937, page 393.

New Altitude Record. It is reported that Colonel M. Peozi has beaten the altitude record for airplanes by reaching a height of 51,361 ft. in a Caproni 161 airplane powered by a Piaggio engine. Brief reference. Engineer, May 14, 1937, page 567.

Piaggio P.32 Two-Engined Bomber. High-speed bomber equipped with two 812-hp. Isotta-Fraschini Asso XI RC engines has a top speed of 420 km. per hour at 4500 meters. Characteristics, performance, armament and construction. A few details and illustrations of the Piaggio P.23 four-engined transatlantic transport, and the P.16 trimotored bomber are included. Rev. de l'Armée de l'Air, March, 1937, pages 349–352. 8 illus.

U. S. A.

Barkley-Grow 8-Place All-Metal Transport. New T8P-1 8-place low-wing transport for feeder-line work is powered by two Pratt and Whitney Wasp Junior SB 400-hp. engines and has a maximum speed of 213 m.p.h. and a service ceiling of 24,000 ft. Construction, equipment, specifications, and performance figures. Aero Digest, May, 1937, page 46, 4 illus.

Bomber Tested. Boeing YB-15 bomber tested in Seattle. Few details and an artist's perspective drawing. Reference is also made to flight of the fourth YB-17 added to the Air Corps fleet, in which the bomber averaged 235 m.p.h. Aero Digest, May, 1937, pages 80–81, 1 illus.

Army Air Corps' 20-Ton Boeing Bomber. War Department announcement regarding the classification of the new Boeing Bomber which is basically similar to the YB-17. U. S. Air Services, May, 1937, pages 18–19, 2 illus.

Beechcraft Cruises at 235. New Beechcraft Model D-17, powered with Wasp, Jr. SC-G engine, surpasses in top and cruising speeds any transport airplane now in service. Specifications and engine and flight instruments. Aviation, May, 1937, page 45, 1 illus.

DC-4. New Douglas DC-4 40-passenger four-engined transport has tricycle landing gear, three-rudder tail and horizontal stabilizer with a marked dihedral. Brief description and comparison of size and performance with those of the DC-3. Aviation, May, 1937, pages 37, 78. 2 illus., 1 table.

Simplexity Itself. Some "cockpit impressions" of the Lockheed Electra, special equipment for British Airways. Comments on design, equipment performance, and radio from the British point of view. Flight, April 22, 1937, pages 384–386, 2 illus.

Transatlantic Flying Boats. For this service six new Boeing flying boats are being built which will weigh over 40 tons each, will accommodate 72 passengers and crew of 8, will be powered by four 1500-hp. Wright engines and will have a top speed of 200 m.p.h. Brief references. Engineer, April 23, 1937, page 479.

Two in One. Waterman W-5 two-place Arrowbile is a combination of road car and airplane, equipped with a Studebaker 6 100-hp. engine, and has a top speed of 120 m.p.h. in the air. Aviation, May, 1937, pages 32–34, 8 illus., 1 table.

Howard Model DGA-9. Ben O. Howard. New four-place commercial monoplane powered by a Jacobs 285-hp. engine and having a cruising speed of 166 m.p.h. Long description by the designer. Aero Digest, May, 1937, pages 70 and 71, 5 illus.

"It's a Good Plane." C. Ryan. Lindbergh's "Spirit of St. Louis" is compared with Miss Earhart's Lockheed Electra, and with present-day medium-weight commercial sport and training planes. Fundamental construction practices and landing gear of 1927 and the present are also considered. Western Flying, May, 1937, pages 15–17, 25, 4 illus.

Lockheed 14 Transport. New 14-place monoplane transport of the mid-wing type powered by Wright Cyclone GR-1820 G-3 840-hp. engines and having a maximum speed of 265 m.p.h. Innovations include commercial adoption of integral fuel tanks and utilization of all-metal Lockheed-Fowler wing flaps, electrically operated. Specifications, performance, and design. Aero Digest, May, 1937, page 54, 1 illus.

Various Notes. Martin Super Clipper, the world's largest transport flying boat to be used on the non-stop transatlantic air service which Glenn L. Martin intends to establish in competition with Pan American and British Imperial Airways. Brief reference to design. U. S. Naval Inst. Proc., June, 1937, page 904.

Winter Parade. "Troops of the U. S. Army Air Corps and one of the new four-motored Boeing bombers,—which, the Americans say, is the biggest, fastest and best in the world." Photograph only. Aeroplane, May 5 1937, page 527, 1 illus.

U. S. S. R.

The Four Winds. A Soviet pilot claims to have taken a twin-engined transport to 29,865 ft. with a load of one ton. Brief reference. Flight, May 13, 1937, page 473.

Aircraft Camouflaging

War Paint. "Shadow shading" schemes adopted by the Air Ministry for R.A.F. single-engined medium bombers, twin-engined medium bombers, and heavy bombers are illustrated and explained. Each class is allotted two alternative systems of coloring, one being the "mirror" image of the other. Systems of camouflage used by the Germans during the war are also explained. Flight, April 29, 1937, pages 408–410, 5 illus.

Aircraft Carriers

Ark Royal. World's most modern aircraft carrier launched for the British Navy is said to have stowage for about 70 aircraft and will be driven by Parsons geared turbines at a maximum speed of about 30 knots. Brief note. Flight, April 22, 1937, page 393d, 2 illus. Aeroplane, April 21, 1937, page 457, 1 illus. Engineer, April 23, 1937, pages 480, 482, 2 illus. Engineering, April 23, 1937, pages 472–473, 2 illus.

Aircraft Maintenance

Air Ministry Official Notices. Instructions to ground engineers and private owners on dial instruments, inspection of the blade sheet of Fairey-Reed metal propellers for transverse fatigue fractures, and handbrake of autogiro. List of approved British aircraft, propeller, aircraft-component, radio, tire, instrument and equipment firms, and of firms specially approved in connection with experimental or test flights. Aircraft Engineering, April, 1937, pages 106–108.

Aircraft Performance Testing

The Measurement of Speeds. A. E. Woodward Nutt. Errors inherent in standard installation for indicating speed, and methods evolved to measure speed—not only top speed but speed generally—to a high degree of accuracy. Effect of air compressibility; errors of A. S. I.'s; position error; location of pitot-static head; suspended static heads and their use; suspended and high-speed air logs and modifications for special purposes; calibration of air logs; speed courses and pilotage on them; aerial observation on low-altitude and high-altitude speed courses and ground observation; Martlesham Heath Railway speed course; camera gun and "loop" methods for measuring speed; effect of wind on speed measurement; and measurement of top speed. Nomograms included for correction of air-speed indicator for compressibility. Long article with editorial comment. Aircraft Engineering, April, 1937, pages 91–96 and 89–90, 9 illus., 1 table.

Air Transportation

"Fortune" Marshalls the Facts. Question of safety in air transportaton. Abstract from Fortune, April issue. U. S. Air Services, May, 1937, page 28, 30.

Ocean Air Transportation. L. C. McCarty, Jr. (See TECHNICAL DATA DIGEST, March 15, page 5 for abstract of preprint.) S.A.E. Jour., May, 1937, pages 13–17, 6 illus., 1 table.

When a Pilot Knows That He Is Where He Thinks He Is, We Are Going to Have Very Few Accidents. Major R. W. Schroeder. Few comments concerning problems yet to be solved in regard to pilot personnel. U. S. Air Services, May, 1937, pages 15–16.

With Airship and Airplanes for Transoceanic Service. "Conquering the North Atlantic," F. F. von Buddenbrock, discussing: the airways over the Atlantic, influence of speed on the flying schedule, question of landplane or flying boat, water and catapult take off, improvement in water take-off, most suitable methods for development of flying boats, new routes for new transoceanic aircraft, and comparison of development in Germany and foreign countries. Rather general discussion. This paper and one by Captain E. A. Lehmann entitled "Experiences on Zeppelin Trips" were presented before the Lillienthal-Gesellschaft fuer Luftfahrtforschung. Luftwissen, March, 1937, pages 65–72, 3 illus.

Air Transport in the Empire. F. D. Bradbrooke. British Empire routes, and present position of air transport in Great Britian, Canada, Australia, New Zealand, New Guinea, and Union of South Africa. Aeroplane, May 12, 1937, pages 587–591, 9 illus.

Transport Beginnings. Early years of British air transport and navigational development. Brief review. Flight, May 6, 1937, pages 454–455, 4 illus.

Propellers

Curtiss Electric Constant Speed Propeller. Method of operation, principles of construction, and installation of the electrically-controlled constant-speed full-feathering propeller originally produced by Curtiss for the military services and now available for commercial aircraft. Performance curves of a typical military airplane are given to show the advantage of the constant-speed propeller. Long description. Aero Digest, May, 1937, pages 48–50, 9 illus.

Curtiss Controllable. Electric constant-speed full feathering propeller. Long description and data on models for dural and steel blades. Aviation, May, 1937, pages 38–39, 73, 6 illus., 2 tables. U. S. Air Services, May, 1937, page 34, 1 illus.

Electric Control. Lycoming electric pitch control for propellers is incorporated in the throttle handle so permitting the pilot, with one hand, to set his engine speed for any desired condition of take-off, climb, or cruising and simultaneously to set the propeller blade angle. Few details. Aviation, May, 1937, page 42.

Gnôme Rhône Constant-Speed Variable-Pitch propeller. Latest Gnôme Rhône variable-pitch propeller operates entirely automatically. Propeller blade setting is carried out by influence of centrifugal forces of inertia masses and air forces on the blade. Electrical indicator for showing blade angle of incidence also described. Details of design taken from Gnôme Rhône Shop News. Luftwissen, February, 1937, pages 54–55, 3 illus.

The Weight of Airscrews. Captain F. S. Barnwell. Increase of specific weight of geometrically similar propellers with brake horsepower. Calculations are given and suggestion made that blades be made hollow on the assumption that it is less difficult to make a large blade hollow. Flight, April 22, 1937, page 394, 1 table, 10 equations.

Aircraft Instruments

Fairchild Hanger Position Finder. J. C. Ochocki. Position finder reproducing with accuracy the motion of any celestial body. Azimuth, declination and hour angle, instead of remaining numerical quantities, are given tangible form in shape and setting of arcs to be manipulated by the operator. Construction and method of operation described. Aero Digest, May, 1937, pages 42–45, 1 illus.

Is the Compass the Cause of Failure in Flights to Japan. Commandant J. Saharov. Compass errors in flights to the Far East from Europe. Les Ailes, April 22, 1937, page 7, 4 illus.

The Principles and Practice of Automatic Control. Pollock Brown deviator, an automatic pilot for aircraft. Long description of design and operation and editorial on the series of articles. Concluded. Engineer, April 23, 1937, pages 467–469 and 481–482, 8 illus.

Remote Reading Compass. West Telemagnetic aircraft compass operates a left and right indicator on the instrument board from an electrical capacity change within the compass itself. Few details. Aviation, May, 1937, pages 48–49, 1 illus.

Airport Equipment

Modern Aeroplane Hangers. A. Mehmel. Most suitable ratios of depth to span for German hangars has been found to be 6:10, 7:10, and 8:10, the lower values being applicable to parking hangars and the higher to repair hangars. Construction of German hangars discussed by member of the German Air Ministry. Brief abstract, Institution Civil Engineers paper. Engineering, May 7, 1937, page 527.

Subterranean Storage. Objections to subterranean storage for aircraft in Great Britian. Aeroplane, May 5, 1937, pages 531–532.

Aerodrome Design. Squadron Leader N. Forman. Landing gear requirements from the point of view of the aircraft so that it may bring in and take out its load in the most economical manner. Size of landing area, effect of altitude and temperatures, gradient, direction of landing, landing surface, and zoning. Jour. Royal Aeronautical Soc., April, 1937, pages 284–296 and (disc.) 297–305.

Aids to Air Transport. Brief notes on British airport equipment. Aeroplane, April 21, 1937, pages 483–488, 13 illus.

Air Transport and the Airport. F. D. Bradbrooke. British airport design from the point of view of the aircraft using it. Aeroplane, April 21, 1937, pages 461–463, 5 illus.

For Hush-Hush Hangars? Unusual method of a British firm for mounting sliding doors said to be silent in operation. Brief reference. Flight April 29, 1937, page 418.

Deicing Equipment

Combating Ice. Dunlop Anticers developed at Farnborough and "Kill Frost" chemical means both tested by Imperial Airways and the former fitted to the D.H.86 with improvements. Brief reference to these two means for preventing ice formation. Flight, April 29, 1937, page 427.

Ice Formation on Aircraft. Only eight of Britain's 150 civil aircraft are fitted with apparatus to combat ice formation. Few details of deicing equipment on four Lockheed Electras of the British Airways and of that developed by the Dunlop Rubber Company with which one of the four-engined air liners of Imperial Airways is fitted. Very brief. Engineer, April 30, 1937, page 509.

Anti-Ice Solution. Solution used by Chicago and Southern Airlines to prevent ice formation near the propeller hub. Brief reference. Aero Digest, May, 1937, page 68.

Lighting Equipment

Aerodrome Lighting Equipment. Various types of British boundary and obstruction lights, and equipment for lighting airways. Engineering, April 30, 1937, pages 486–488, 11 illus.

The Airport Lighting Specifications of the Department of Commerce. F. C. Breckenridge. Two specifications covering installation and performance of airport lighting equipment are analyzed. Trans. Illuminating Engg. Soc., April, 1937, pages 421–436, 3 illus., 1 table.

Recent Developments in Aviation Lighting. H. C. Ritchie. New equipment for airport lighting, including beacons, boundary and obstruction lights, field floodlights, runway marker lights, airplane headlights, and airplane position lights, and further problems for the illuminating engineer, especially with respect to lighting required for bad weather landings. Discussion included. Trans. Illuminating Engg. Soc., April, 1937, pages 436–451, 8 illus.

Parachutes

Daredevils of the Sky Find New Uses for Parachutes. A. R. Boone. 'Russia now plans to construct 1000 jumping towers on which to train 1,000,000 parachutists during the next year.'' Dropping of supplies from bombers in Ethiopia, a Russian "blind landing" by parachute, Russian maneuvers with soldier parachutists, a giant parachute for dropping an airplane to be tested by Colonel R. Turner, sensations of the jumper, and results of tests obtained by Captain H. G. Arsmtrong are reviewed briefly. U. S. Air Services, May, 1937, pages 20–22, 36, 2 illus.

Preparachuting. "Nerve soothing" training methods now being adopted in the United States and European countries for training parachute jumpers. Recent Russian maneuvers in dropping armed soldiers, and Italian and French experiments in dropping troops are referred to and the four phases for training parachutists developed by the American Armament Corporation's scheme are described in detail. Flight, April 22, 1937, pages 392b–392c, 7 illus.

Training for Parachute Jumps. Training system and parachute tower developed by J. H. Strong and used by the Navy. Short description. Scientific Am., June, 1937, pages 386–387, 4 illus.

Photography

The Camera in the Air. F. L. Wills. Progress made in England in regard to oblique aerial photography, air survey, interpretation, stereoscopic inspection, cartography, mosaics, weather conditions, and large-scale plans. Photographs taken from the stratosphere ballon Explorer II referred to. Photographic Jour., April, 1937, pages 279–286, 288, 9 illus.

Engine Design and Research

Aero Engine Development. Some British 1911 types compared with present power plants and review of development from 1911 to 1937. Flight, May 6, 1937, pages 460–461, 11 illus.

Carbon Monoxide in Engine Exhaust Using Alcohol Blends. L. C. Lichty and C. W. Phelps. Exhaust-gas analysis of the products of combustion from several engines under various operating conditions, with gasoline and two alcohol-gasoline blends, and at various air-fuel ratios. Tests determined the effect of alcohol upon the exhaust-gas analysis both at the same and comparable air-fuel ratios, and at the maximum torque, or at other percentages of maximum-torque air-fuel ratios. Industrial and Engineering Chemistry, Ind. Ed., May, 1937, pages 495–502, 11 illus., 2 tables.

The Diesel Problem. Captain A. Swan. Progress and problem of the compression-ignition engine, and contemporary development of the gasoline engine discussed by head of the Engine Department, R.A.E. Promise of the former is measured in terms of achievement and further promise of the latter. Results obtained at the R.A.E. in 1927 by H. B. Taylor with a single-cylinder compression-ignition engine are described. A table gives particulars of the Packard, Clerget, Bristol Phoenix, Jumo IV and Z.O.D. 240A experimental engines. Both four- and two-stroke compression-ignition engines are considered. Flight. May 13, 1937, pages 478a–478d, 9 illus., 1 table.

Auxiliary Propulsion. Scheme of C. J. Stewart and F. W. Meredith of the R.A.E. for supplementing propeller thrust by that exerted by a mixture of air and exhaust gases pouring from slits in the trailing edge. Brief description. Flight, April 22, 1937, page 397.

Development of the Two-Stroke Cycle Oil Engine. W. S. Burn. Double-acting combustion chambers, pistons, bearings, comparison of single- and double-acting engines, double-acting construction, and high-speed two-stroke engines. Institution Naval Architects paper. Engineer, April 23, 1937, pages 490–492, 5 illus.

Factors Influencing Wear of Valve Seats in Internal Combustion Engines. C. G. Williams. Effects on exhaust-valve temperature of speed, load, alcohol fuels, valve-guide design, valve-stem diameter, compression ratio, cylinder-head material, cooling-water temperature, mixture strength and ignition, and seat width as well as measurement of thermal expansion of inserts. Test results with various valve-insert materials and valve steels. Engineering, April 23, 1937, pages 475–476, 4 illus., 2 tables.

Power Plant Trends. G. J. Mead. Trend of last decade and probable future developments in aircraft engines. Discussion of opportunities for improvement to existing types covers: use of fuels with higher knock rating, additional displacement, better cooling, greater boost, higher operating speeds, lower fuel consumption, higher compression ratio, equal distribution of charge to cylinders, and sleeve valves. Powers likely to be required and influence of power plane on aerodynamic efficiency of the airplane as a whole are analyzed including: number per airplane, power-plant form and cooling drag, propellers, and weight. Types for greater output are discussed in regard to cylinder size, connecting rods, crankshafts, balance and torque, number and arrangement of cylinders for a specific output, and multishaft engines. Placing the engines entirely within the wing is considered. Royal Aeronautical Society paper. S.A.E. Preprint for Meeting, May 4–9, 1937, 36 pages, 14 illus. Aeroplane, April 28, 1937, pages 511–515, 30 illus.

Long abstract and discussion by D. R. Pye, A. H. R. Fedden, Major G. P. Bulman, Major F. M. Green, R. Banks, W. S. Farren, and Major B. C. Carter before the Royal Aeronautical Society. Flight, April 29, 1937, pages 414–418, 14 illus.

Engine Testing

The Art of Dynamometry. N. S. Muir. Art of dynamometry with particular reference to measurement of engine power in flight. This issue deals with a very long review of development ending with the Moullin torsiometer in 1924. Continued. Royal Aeronautical Soc. paper. Aircraft Engineering, May, 1937, pages 126–135, 36 illus., 1 table.

Engine Manufacture

Plant Layout and Production Methods for Modern Aircraft Engines. J. C. Ward, Jr. Important part played by inspection and quality control at Pratt and Whitney, method of fitting it into the production scheme, and meeting special Army and Navy requirements. S.A.E. Jour. (Trans.), May, 1937, pages 178–189, 25 illus., 2 tables.

Engines

Today's Power Plants. Details of British aircraft engines. Bristol Hercules 14-cylinder sleeve-valve aircooled radial engine and Rolls-Royce Merlin 12-cylinder liquid-cooled Vee engine illustrated. Aeroplane, May 12, 1937, pages 585–586, 4 illus.

Parts and Accessories

Piston-Ring Compressor. Wilkening piston-ring compressing outfit. Few details. Aero Digest, May, 1937, page 68.

Army Approves New GM Air Engine. Allison V-1710 liquid-cooled aircraft engine, equipped with a turbo-supercharger, maintains its ground level output of 1000 hp. up to an altitude of 25,000 ft. Few details. Automotive Industries, May 1, 1937, page 643.

Big Engines. New A.B.C. Motors auxiliary engine, designed for duties on flying boats and other large aircraft, is an overhead-valve flat twin developing 5 hp. at 4000 r.p.m. Built into the unit are a 350-watt dynamometer and a gear box by which the engine may be made to drive a refueling pump, a bilge pump, and two air compressors. Few details. Flight, April 22, 1937, page 393, 1 illus.

Lycoming Announces Refinements. Improvements incorporated in the R-680-D 9-cylinder radial engine developing 260-hp. at 2300 r.p.m. are described. Aviation, May, 1937, page 42, 1 illus., 1 table.

The Return of the Native. "Magnificent performance figures are claimed by their makers, but in service, our mechanical French friend asseverated, they had a nasty habit of breaking things inside.'' Brief reference to French aircooled radial engines. French Air Authorities are said to be so disappointed with their performance that a large order has been placed in the States for two-row radials. Breguet and friends are said to be negotiating for twin-row Pratt and Whitney Wasps. Aeroplane, April 21, 1937, page 451.

The Swing of the Pendulum? Allison V-1760-C6 "hot-cooled" 12-cylinder vee rated at 1000 hp. at 2600 r.p.m. Preliminary data and reference to materials. Very brief. Flight, April 22, 1937, page 394.

Three Engineers in the United States. R. Beauvais, A. Glowinski, and Y. Mouraud. Comments on American aircraft engines made by three engineers of the Gnôme Rhône engine company as a result of a visit to Wright Field, the N.A.C.A., Langley Field, M.I.T. and some commercial organizations. Les Ailes, April 22, 1937, page 8, 1 illus.

Accessory Gear Box. Romec accessory-drive gear box described groups all the necessary distributing mechanism in a single unit outside the engine crankcase and contains eight power outlets for accessories. Aviation, May 1937, page 48, 1 illus.

Exhaust Ring. Engel streamlined exhaust ring especially applicable to use with N.A.C.A. cowling. Brief reference. Aviation, May, 1937, page 49, 1 illus.

Hydraulic Starter for Aircraft. Hydraulic starter built under Berger license and used on the Louis Coatalen Diesel aircraft engine. Brief description and illustration of starter mounted on the Coatalen engine. Automotive Industries, April 24, 1937, 2 illus.

Motor Vehicle Supercharger. New type rotating-vane supercharger known as "Centric." Few details. Engineer, April 30, 1937, page 516, 1 illus.

To Control Oil Temperature. American Clarke viscosity valve approved by the Air Ministry and used on the latest Hawker aircraft. Short description. Aeroplane, April 28, 1937, page 522, 1 illus.

Two Breeze Products. Exhaust-gas analyzer and fuel and oil tanks. Brief reference. Aviation, May, 1937, page 49, 2 illus.

Reaction Propulsion

Research on Reaction Motors. Formulas for efficiency, the Mélot reaction blower, forced blowers, American tests, venturi tubes, and ejectors. L'Aerophile, March, 1937, pages 62–64, 8 illus., 6 tables, many equations.

Metals

Sheet Metal Working Processes. Deep drawing and a new process, called stretching, practiced at the Junkers plant for working metal for various components of airplanes. Aircraft Engineering, April, 1937, pages 104–105, 9 illus.

Effect of Protective Coatings on the Corrosion-Fatigue Resistance of Steel. D. G. Sopwith and H. J. Gough. Steel for streamline wires for aircraft. Protective effect of various types of coating on the resistance of 0.5 percent carbon cold-drawn steel, used for aircraft wires, when subjected to alternating stresses in the presence of a spray of salt water. Results of investigation forming part of joint program of research on corrosion-fatigue at the National Physical Laboratory and the Royal Aircraft Establishment. Long abstract, British Iron and Steel Institute paper. Engineering, May 7, 1937, pages 533–535, 1 illus., 3 tables.

Magnesium Alloys. C. H. Desch. Light magnesium alloys suitable for aircraft construction. Progress in development is reviewed by the Superintendent of the Metallurgical Department, National Physical Laboratory. Heat treatment of castings, hardening by aging of forged alloys, and conditions affecting forging at various temperatures are considered. Connection between these properties and the crystalline structure of magnesium is shown. Wrought alloys, magnesium alloys at high temperatures, and protection of propeller surfaces are also covered. Jour. Royal Aeronautical Soc., May, 1937, pages 369–381 and (disc.) 381–387, 4 illus., 4 tables.

Aircraft Radio

Aero Radio Digest. RCA aircraft radio direction finders on American Airlines Flagship Sleepers, blind-landing system proposed by E. M. Sorensen of Wright Field and assigned to the War Department, TWA direction-finder dial having correction for electromagnetic effect of airplane structure, and Model E Simon Radioguide flight tested in American Airlines Douglas. Aero Digest, May, 1937, page 64, 2 illus.

Inevitable Inventions in Aircraft Radio. H. W. Roberts. Two methods of absolute altitude indication, radio-controlled gyropilot, short-wave 360° direction finder, radio drift indicator, radio marker beacons, and electromagnetic cable for guiding aircraft safely over electrically difficult terrain. Aircraft navigation needs said to be technically feasible with the knowledge now available. Aero Digest, May, 1937, pages 56, 58, 2 illus.

Radio Signpost for the Airport. New radio range system developed by United Airlines and providing positive radio identification of airport location. Few details. Scientific Am., June, 1937, page 387, 1 illus.

The Radio Situation. Present position of directional radio for air transports in Europe and comparison with American methods. Aeroplane, May 12, 1937, page 592, 2 illus.

Air Landing Signals Systems Are Argued. Few points brought out by Captain G. V. Holloman and I. R. Metcalf on the Army Signal Landing System, and the Bureau of Air Commerce and German Lorenz systems at the Indiana Section blind-landing meeting. Brief. S.A.E. Jour., May, 1937, page 32, 1 illus.

Experimental Tests on the Maximum Radio Direction-Finding Methods. H. Failer. Most of the present radio direction-finding methods are based on the determination of the incident direction of electromagnetic waves according to the sound intensity medium. Purpose of research described is to apply the maximum of the directional characteristic for the bearing in order to eliminate the prevailing disadvantages in the case of other methods. Required maximum peak of the direction-finding characteristic is obtained by a difference method or by control connections. Report of Telegraphic and Radio Test Station, Grädfelfing. Luftfahrtforschung, March 20, 1937, pages 148–152, 11 illus.

Modern Radio in Air Transport. Advantages and objectives to the four distinct types of radio aids to navigation, including: communication from ground to airplane and back again, and from airplane to airplane; homing on any convenient radio station; radio beam providing an invisible track along which an airplane can fly from airport to airport; and the Lorenz system of blind approach. Aeroplane, April 21, 1937, pages 464–465, 3 illus.

New Blind Landing Beacon Has Antenna Underground. Pit antenna is found to give steeper and more satisfactory approach path for landing airplanes. Brief abstract of paper by H. Diamond and F. W. Dunmore, recently presented before the Institute of Radio Engineers. Science News Letter, May 8, 1937, page 292.

"Q. B. I." J. Millar. How the British handle their airport traffic control when the fog rolls in. Three important radio-controlled areas, operation of control, control approaches, direction-finding service, weather report service, and blind approach and landing installations. Aviation, May, 1937, pages 22–23, 76, 4 illus., 1 table.

Aeronautical Industry and Production

The Four Winds. In spite of demands of the expansion program British exports of airplanes, engines, and components during 1936 attained a record figure of nearly £3,000,000. Brief reference. Flight, April 1, 1937, page 323.

Los Angeles Lights a Merchandising Match. Review of exhibits at the National Pacific Aircraft and Boat Show. Aviation, May, 1937, pages 24–25, 76, 78, 3 illus.

New Laboratory. Research and engineering addition to Eaton Manufacturing Company's Detroit plant for increasing facilities in experimental and development work in automotive and aircraft fields. Brief reference. Automotive Industries, May 15, 1937, page 719, 1 illus.

News from Nippon. Three Japanese companies now organized to produce aircraft in the complete form are hampered by skilled labor shortage, and American aircraft concerns are reported less disposed to release licenses or to admit foreigners to their workshops. Brief reference. Automotive Industries, May 15, 1937, page 716.

Notes. Construction rights for the Schwarz light wood propellers have been given to the American Engineering and Research Corporation. Brief reference. Luftwissen, February, 1937, page 54.

World Trade in Military Aircraft. Existing stock of military and civil aircraft, and construction programs of the various countries as compiled by Bendix Aviation Corporation. From Interavia. Aeroplane, April 21, 1937, page 452, 2 tables.

Increase in North American Aviation contract for Army Air Corps basic training planes, foreign government orders received by Vultee, and four-point program of Wright Aeronautical factory expansion. Brief references to these items and to new aircraft assembly hall of Glenn L. Martin Company. U. S. Air Services, May, 1937, pages 31, 36.

Meteorology

Atmospheric Waves on Isentropic Surfaces As Evidenced by Interfrontal Ceiling Oscillations. W. C. Jacobs. Ceiling oscillations observed at the Weather Bureau Airport Station, San Diego, method of determining ceiling heights, barometric oscillations in conjunction with the waves, mathematical analysis of data, and comparison of waves on air and water surfaces. Monthly Weather Rev., January, 1937, pages 9–12, 1 illus., 6 equations.

The Development of a Radio-Meteorograph System for the Navy Department. H. Diamond, W. S. Hinman, Jr., and F. W. Dunmore. Radio meteorograph with pressure drive, temperature unit, radio meteorographic equipment, ground-station receiving equipment, calibration and performance, sample record of an ascension, ascensional rate of balloon, other uses of the pressure-switching method, hygrometer, and determination of upper-air wind conditions by radio direction finding. Long descriptions. Bul. Am. Meteorological Soc., March, 1937, pages 73–99, 20 illus.

The Finnish Radio-Sound and Its Use. V. Väisälä. Important improvements in the sounding instrument and tests made. Abstract from Societias Scientiarum Fennica, Commentationes Physico-Mathematicae. Bul. Am. Meteorological Soc., March, 1937, pages 126–128, 2 illus.

Radio Equipment for Harvard Radio-Meteorographs. A. E. Bent. Circuits developed, and their use. Meteorological part of the instrument and its technique is described in a second article by K. O. Lange. Bul. Am. Meteorological Soc., March, 1937, pages 99–107 and 107–126, 14 illus.

Air Forces

Outline of an Equipment Program for Naval Aviation. Captain P. Barjot. Naval pursuit aviation. Discussion includes: return to pursuit seaplanes; four different types for 60 pursuit airplanes; the British example of using only one type for naval pursuit; retractable landing gear; flotation gear; aerodynamics of landing on platforms; dive bombing connected with single-seat pursuits; two-place pursuits; cannon in naval pursuits; and importance of cannon for attack on submarines. Naval airplanes and seaplanes of France and other countries, especially of the United States, are illustrated and discussed. Table gives characteristics and armament of single and two-place pursuit, bombardment and observation airplanes of the United States Navy in service or in tests in 1936. Rev. de l'Armée de l'Air March, 1937, pages 287–312, 20 illus., 1 table.

Martin Boats for the Far East. First 62,000-lb. flying boat sold to a foreign power. Brief reference. Aeroplane, April 21, 1937, page 452.

ARGENTINA

The Four Winds. Argentine War Ministry has placed contracts for the supply of 110 machines, 20 to be constructed in Germany and 90 in the United States. Brief reference. Flight, April 29, 1937, page 420.

AUSTRIA

Growth of Austrian air force, appeal for contributions to the air force, anti-aircraft defense, and parachute training. Brief notes. R.A.F. Quarterly, April, 1937, pages 227–229.

BULGARIA

Air exercises, and government support for aviation. Brief reference. R. A. F. Quarterly, April, 1937, page 229.

DENMARK

Copenhagen Volunteer Air Defense Corps of 750 men. Brief reference. R. A. F. Quarterly, April, 1937, page 229.

FRANCE

Reorganization of the French Air Force, territorial and operational, command, popular parachute associations, college for higher studies of National Defense. Brief notes. R.A.F. Quarterly, April, 1937, pages 229–231.

GERMANY

Difficulties in the German-Rumanian oil trade, volunteers for German air force, air force exercises, air force displays on "Reich Party Day," air raid precautions, types of aircraft in the German air force, its organization, fire-resisting paint for wooden structures, and other air-defense measures. Brief notes. R.A.F. Quarterly, April, 1937, pages 231–237.

Reich Armaments. Germany has tripled her air force in the last year to a total of more than 2000 war planes and bombers. Number of equipment and personnel in the air force, Army, and Navy briefly referred to. U. S. Naval Inst. Proc., May, 1937, page 734.

GREAT BRITAIN

The Air Estimates for 1937. Memorandum by the British Secretary of State for Air considering: general policy, substantial progress in the expansion program for the R.A.F., financial summary, new squadrons, first line strength of 1750 machines, personnel and training, auxiliary air force, reserves, technical equipment, research, "shadow" factories, new training centers, Air Ministry, and abstract of Estimates. R.A.F. Quarterly, April, 1937, pages 214–222, 2 tables.

Air Ministry Contracts. List of orders placed by the British Air Ministry during the month of February, not including quantities or costs. Aircraft Engineering, May, 1937, page 139.

Aircraft and the Navy. Rear Admiral H. G. Thursfield's views on Naval control of the Fleet Air Arm, and utility of aircraft to a fleet. Quotation from 1937 issue, "Brassey's Naval Annual" in brief editorial. Flight, May 13, 1937, page 467.

Looking Ahead. Special strategic Air Command, available for duty anywhere in or outside of the Empire, when necessary, is considered as the next need in the expansion program. Editorial. Flight, May 13, 1937, page 465.

The N. W. Frontier Operations. Cooperation of R.A.F. airplanes with British and Indian troops in South Waziristan where the Fakir of Ipi and his supporters are in rebellion against authority. Brief account. Aeroplane, May 12, 1937, page 559.

On the Air Power of the British Empire. C. G. Grey. Political situation in Europe as it is influenced by air power, and protection of the British Empire in general and England in particular. Aeroplane, May 12, 1937, pages 571–576, 2 illus.

The Royal Air Force in the New Reign. C. M. McAlery. Present organization of the Metropolitan Air Force, Overseas Command, and personnel. Long description and reference to equipment. Aeroplane, May 12, 1937, pages 565–570, 12 illus.

Links in the Air Defense Chain. W. MacLanachan. Problems of cooperation between fighters and searchlights in England. Conditions under which fighter squadrons will work at night, and the suggestion that the Air Force assume complete control of all searchlights, maintaining them on a Territorial basis as Auxiliary Air Force. Flight, April 22, 1937, pages 398–399, 4 illus.

Royal Air Force Expansion. Progress in new stations, increase in strength, recruitment and training of personnel, and volunteer Reserve scheme. Brief summary of position. R.A.F. Quarterly, April, 1937, pages 223–225, 1 table.

A Visit to Malta. A. E. Barlow. Headquarters of R.A.F. Mediterranean Command. Flying boat station at Kalafrana, Queen Bee radio-controlled float planes to provide anti-aircraft training targets, catapult units, stores depot, and Hal Far airport. Aeroplane, April 28, 1937, pages 507–510, 7 illus.

ITALY

Air Force organization, flags for air regiments, airports and aircraft industry, army maneuvers, experiments in Libya. Brief notes. R.A.F. Quarterly, April, 1937, pages 237–239.

JAPAN

Defense Plans. "Japan's chief fear was that United States air units in Alaska, the Aleutian Islands, Hawaii, and other Pacific possessions would be increased." Statements of Japanese military and naval officials to the Diet are briefly quoted. U. S. Naval Inst. Proc., May, 1937, page 737.

SIAM

The Four Winds. Siamese Government has ordered a number of Martin twin-engined bombers. Brief ref. Flight, April 29, 1937, page 420.

SWEDEN

German Ju-86 bombers for the Swedish air force, appointment of committee to establish an experimental aerodynamics institute, German influence in Sweden, and flying instruction for general staff officers. Brief notes. R.A.F. Quarterly, April, 1937, pages 239–240.

U. S. A.

"Following exhaustive tests by the Air Corps in conjunction with Infantry, Artillery, and Cavalry over a period of approximately 1½ years, the War Department has purchased six autogiros." Brief reference to speed and uses. Army Ordnance, May–June, 1937, page 370.

An Ambassador at Large. "The U. S. Army Air Corps has put a batch of its instructors through the course which was evolved by the Bureau of Air Commerce and is remarkably pleased with the result." Brief references to method of training pilots on the Link trainer and under a hood in the air, and to three defects in American airline operation. Comments by Lieut. Colonel J. Carroll Cone in England. Aeroplane, April, 1937, pages 497–498.

Armada Amassed. Consolidation of 244 airplanes of the GHQ Air Force for maneuvers on the Pacific coast. Few details. Aviation, May, 1937, page 57.

Aircraft carriers under construction, Army Air Corps contracts for 120 North American O-47 observation airplanes, and Naval Air Service contracts for Consolidated patrol bomber flying boats and Vought scout bombers. Brief notes. R.A.F. Quarterly, April, 1937, pages 240–241.

The Four Winds. "Tricycle landing gear is being tested on an OA-4B amphibian by the U. S. Army." Brief reference also to a routine transfer of aircraft from the U. S. A. to Honolulu completed non-stop by new Consolidated PBY-1 flying boats manned by a crew totalling eighty. Flight, April 29, 1937, page 420.

Reorganizing the Air Corps. Bill introduced in House of Representatives by Congressman Wilcox, said to present a plan for reorganizing the Air Corps under the Secretary of War, and to allow a degree of autonomy even greater than that now accorded to the Marine Corps within the Navy Department. Editorial. U. S. Air Services, May, 1937, pages 9–10.

United States Air Force Just Misses Cellar Position. R. S. Findley. "Drops Down Another Peg to Sixth Place—Is Only 200 Airplanes Ahead of Japan." Aircraft year book for 1937 REVIEWED and table of estimated combat strength given. U. S. Air Services, May, 1937, pages 14 and 32, 1 illus.

Going Hollywood. "Northrop attack machines of the U. S. Army Air Corps . . . These machines are intended primarily for ground strafing and apart from one free and four fixed Brownings are equipped for the dispensation of chemicals." Flight, May 13, 1937, page 466, 1 illus. Photograph only.

Air Warfare

Aviation and the Tanks. C. Rougeron. Use of airplanes for stopping a ground attack of tanks, and the arms required are discussed in great detail. Tactical and strategical problems in the use of airplanes against tank attacks, and use of the aerial arm in ground struggles are also considered. Rev. de l'Armée de l'Air, March, 1937, pages 249–286 and 243–248, 5 tables.

Fire Over London. Cy Caldwell. "London has the best defense against air attack yet evolved . . . During the next five years the British Government will spend $7,500,000,000 on war preparedness. . . In five years England will have more than 15,000 first-time fighting planes in all categories." Tactical problems involved in the destruction of London by fire. An attack by a force of 500 bombers over London at midnight is discussed, plan for attack planes outlined and main bombardment attack described. Aero Digest, May, 1937, pages 21, 95–96, 1 illus.

On Stories from Spain. C. G. Grey. Bombing of Guernica, sinking of the Nationalist battleship España, and unreliability of newspaper reports. Aeroplane, May 5, 1937, pages 528–530.

Why Should the United States Have Airships? Lt. Commander F. H. Gilmer. Need for airships in case of war and evidence from the last war. U. S. Naval Inst. Proc., June, 1937, pages 806–809.

Views on Air Defence. Authors of "Air Strategy." Use and place of aerial combat as a means of strategic defense. Increase of maximum speeds obtainable, as calculated from prototype performances with 1936 airfoil sections, is given for destroyer, high-performance bomber, scout and light S. S. fighter. Interception of hostile aircraft is discussed with a table of speeds of fighter and bomber and distance to overtake the bomber, and a detailed calculation is made of how far ahead of fighter airports the observation posts must be located.

Design of a searchlight-carrier-airplane is illustrated for finding enemy planes at night and for furnishing adequate illumination for fighters in their attacks. Designs of a destroyer and high-performance bomber are described, the latter being converted into an auxiliary searchlight craft by the fitting of a special nose to the fuselage to replace that carrying bomb-aiming equipment. Reference is made to the Independent Air Force, previously suggested, which will have a combination of two destroyer wings with one wing of high-performance bombers to form a single group, and a searchlight carrier. To be continued. R.A.F. Quarterly, April, 1937, pages 101–117, 5 illus., 5 tables.

The Abyssinian War. L. Hart. "Mechanization in the broad sense was the foundation on which the Italian's military superiority was built, while aircraft, the machine gun, and mustard gas proved the decisive agents." Lessons taught by the war. Army Ordnance, May–June, 1937, pages 325–331, 1 illus.

Air Operations. C. Rougeron. Speed of bombers, their armament, and comparison of bomber and fighter in actual combat. General Douhet's opinions are quoted and criticized. Translation from "L'Aviation de Bombardment." To be continued. R.A.F. Quarterly, April, 1937, pages 118–140.

Aircraft Depth Charges. About ten depth-charge aircraft would cross the course of the attacking bombing squadron some 1000 ft. ahead and above, and would drop their charges building a curtain of greatest explosive force with a width of 500 yards and a depth of 3500 ft. across the course of the enemy. Brief reference to plan proposed by P. Melon in France. U. S. Naval Inst. Proc., May, 1937, page 748.

Blimp Redivivus. W. O. Manning. Small nonrigid airship as a factor in antiaircraft defense, in observation at sea and as aerial listening posts. Experimental facilities in England are also discussed. It is suggested that the North Sea type, developed towards the end of the world war and brought up to date, would fulfill the requirements. Flight, April 22, 1937, pages 387–388, 3 illus.

Ramming Attack Against Bombers. Rammer aircraft should be capable of intercepting enemy bombers, should be able to operate day or night at high altitudes, and should be in R.T. communication with the ground. To enable the pilot to get clear after collision, his cockpit should be placed as far aft as possible and he should be able to jettison himself complete with oxygen apparatus when operating at great heights. General design of a rammer aircraft is described and illustrated. Difficulties in destruction of enemy air forces, case for rammer aircraft, method of attack, and bomber defense against rammer aircraft are discussed. R.A.F. Quarterly, April, 1937, pages 141–146, 2 illus.

War in Spain and Its Lesson. A. Langeron. First issue—Lessons taught by air warfare in Spain with recommendations for their application to the French air force. Second issue—The third lesson showing the real cooperation which can be established between the air force and the Army on the Ground. Les Ailes, April 8 and 15, 1937, pages 12 and 13.

Miscellaneous

Fast from Afar. Australia-England flight of H. F. Broadbent in a D.H. Leopard Moth in 6½ days, and the flight of H. L. Brook from the Cape in a Percival Gull in 4 days. Brief accounts and lists of equipment. Flight, May 13, 1937, page 472. Aeroplane, May 12, 1937, pages 595–597, 5 illus.

A Good Line in Pumps. Tecalemit rotary pump can be used to pump, or be driven by, oil, water, air, or any other fluid and has been developed to operate gun turrets, retractable landing gear, and other hydraulic devices. Another form of pump being developed has four blades, two fixed abutments and two separate sets of inlet and outlet ports. Aeroplane, May 5, 1937, page 551, 3 illus. Flight, May 13, 1937, page 488, 2 illus.

Oxygen Regulator. Gaertner Model O-5-A oxygen regulator for automatic and positive supply of oxygen to pilots operating at high altitudes. Brief description. Aero Digest, May, 1937, page 68.